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Requirements and Basic Structural Types of Farm Ponds — *Robert S. Calkins*

Human Advancement Through Agricultural Engineering — *Ross E. Moore*

Some Modern Hay Harvesting Machinery — *P. A. Whisler, C. B. Richey, O. F. Scholl, F. D. Jones*

Safe Lightning Protection Assured for Farm Buildings — *R. D. Bienemann*

The Use of Strain Gages for Farm Equipment Design — *Sherman C. Heth*

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THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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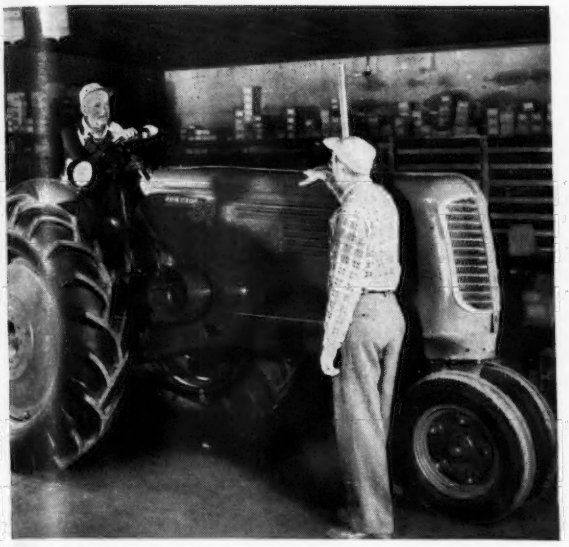
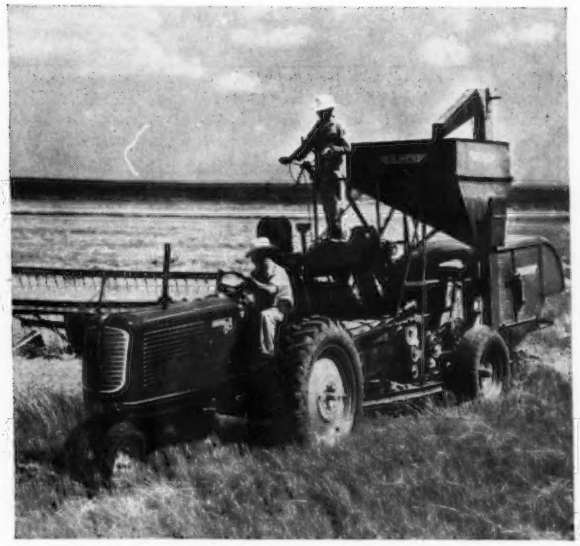
CASE ☆ ☆

EDUCATIONAL MATERIAL ON ADVANCED PRACTICES. In cooperation with the Soil Conservation Service and other agricultural authorities Case has prepared movies, booklets, etc., of educational value. Most of the films are in full color and sound; all are in 16 mm. width. Several have parallel booklets of similar scope. Charts and posters are suited to classroom and exhibit use. Some of the subjects are terracing with plows, building ponds, making high-protein hay. Send for booklet, "Visual Education Materials." J. I. Case Co., Racine, Wis.

Why 8 out of 10 tractor owners prefer gasoline



The extra power, convenience and economy of gasoline are important reasons why eight out of ten tractor owners are using this fuel. Gasoline gives more power in a tractor, is most efficient when used in a modern, high compression engine specifically designed for it.



Over half of all tractors in service today have high compression, gasoline engines. High compression engines squeeze more power from every drop of fuel. As a result, using the same size tractor, a farmer can do more work in a day, operate in higher gear, pull more equipment.

The new Oliver 88 features a 6-cylinder high-compression engine with a 6-speed transmission to provide practically any combination of drawbar pull and ground travel. This big 3- and 4-plow Oliver tractor is also equipped with a continuous running power take-off.

The farmer lives with his tractor. Therefore it's vital that he get one that will do his work efficiently and economically. When you recommend a high compression model, you are helping him get features he wants now and will continue to want. *Ethyl Corporation.*

AGRICULTURAL ENGINEERING

Established 1920

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RAYMOND OLNEY
Editor and Business Manager

EDITORIAL

Engineering Influences on Civilization

IN HIS address at the dedication of the Agricultural Engineering Institute, University of Hawaii, H. B. Walker provided some unrationed food for thought on the nature, significance, and obligations of agricultural engineering.

By inference he answers the question of ultimate justification of agricultural engineering and of the whole range of material progress to which it is related.

"Modern farming is no longer a mode of life. Agriculture has joined the industrial class."

Agriculture as a primitive mode of life, with all its acknowledged stoic virtues, left something to be desired — in capacity to support and to share in other possibly desirable modes of life; in recognition and development of the inherent worth of the individual human life; in the development, utilization, and conservation of natural resources.

It is a part of the philosophy of material progress that the virtues developed by the primitive agricultural mode of life can also be developed by other means, that character can be developed by means other than privation, that abundance of the necessities of life can be applied to the realization of values higher than those of decadent soft living and self-indulgence, that material progress can be used to advance human progress rather than self-destruction.

If our sense of values is somewhere near correct, the ultimate justification of agricultural engineering may depend on the truth of that philosophy.

"Most of the products of engineering skill, while based upon the inimitable laws of nature, are inanimate things, capable of use for good or evil depending upon the thoughts and subsequent actions of those who foster their development and use."

Examples of misuse of the products of engineering are common. At times it may seem likely that material progress will ultimately end in self-destruction. Few people have shown the capacity or disposition to substitute for the natural rigors of primitive life, a self-imposed discipline or unselfish interest adequate to maintain their mental and moral fiber — to stand prosperity — for more than a few generations. Complete adaptation to new conditions, even the changes of material progress, is difficult for the human race. But people can adapt themselves to new conditions only by experiencing them. That is the way of progress of civilization. Most people are willing to take the risk involved in having one load or another removed from their shoulders. If the result is not all gain, it still may be better than continuing to carry the load. If civilization is desirable, it seems desirable for people to have the opportunity to adapt themselves to the reduced physical strain, and the increased mental and moral responsibility of life with the products of engineering.

Engineers are not alone in fostering the development and use of the products of engineering. They can, by their "thoughts and subsequent actions," influence but not entirely control the use of their products for good rather than evil.

Their influence can be exerted in their technical work by design favoring beneficial use, and by conscious effort to guide the users of their products. It can be exerted in their personal lives by precept and example in keeping with the educational advantages they have enjoyed. It can be applied to increase the material rewards and satisfactions of productive labor and human industry. It can help to "set the patterns for cultural and scientific development."

Agricultural engineers are helping the farming population to shape its pattern as an intelligent, substantial, highly productive group, living comfortably in close association with and advanced understanding of nature, practicing private enterprise in the development and conservation of natural resources for the production of vital necessities for the whole population. This combination of associations, objectives, and conditions appears to favor further adaptation of farmers to the changes of material progress; to use of the products of engineering with a minimum of misuse. In fact, it appears to favor the further advance of farmers and farming as a source and manner of strong leadership in the progress of civilization.

World Interest in Ag Engineering

IT IS of passing interest to note that membership in the American Society of Agricultural Engineers outside of the continental United States has increased more than 50 per cent in a little more than a year.

The membership directory published in May, 1946, showed 90 members outside the United States. The new directory now in production will show 140 or more members so located.

Perhaps the most notable increase is in India, where the number of members has jumped from 2 to 13. Also there is now at least one member in each of several other countries where there have previously been none.

Several factors have contributed to the increase. A number of citizens of this country are in these other parts of the world on temporary or long-term missions to introduce the knowledge and practice of agricultural engineering. Their words and work, and those of others in the same field, are beginning to bear fruit.

In some cases, as with Mason Vaugh and Max Strong in India, they have provided professional training in this field which has increased the numbers of other nationalities qualified for membership.

Undoubtedly the postwar food shortage has been a factor in increasing the interest of various governments and individual leaders. In other cases agricultural engineering has been seen as a natural part of broad programs in the development of natural resources.

Perhaps the leaders of some of the primitive countries recently visited by mechanized warfare could see beyond this to possible constructive use of the devices of engineering.

Agricultural engineering is beginning to take hold, in agricultural countries the world over, as a field of applied science which gets at the subsistence or basic production roots of their economy. They look to us for leadership. It will be worth while for us to continue to justify their confidence.

Obtaining Support for Research

ADVISORY groups on agricultural engineering research are no new development. Some have disbanded after fulfilling the specific purposes for which they were organized. New ones are being organized at intervals to guide and encourage agricultural engineering research in specific areas and institutions. They provide a practical working basis for mutual understanding and cooperation of groups interested in the results which can be obtained by harnessing the power of engineering and other sciences to the work to be done by agriculture.

Steps were initiated late in 1946 to establish the Ohio Agricultural Engineering Council. Its announced purpose is "To promote and assist in the advancement of the science of engineering as it applies to all phases of agriculture in order to bring about improved living conditions and a more efficient production on Ohio farms."

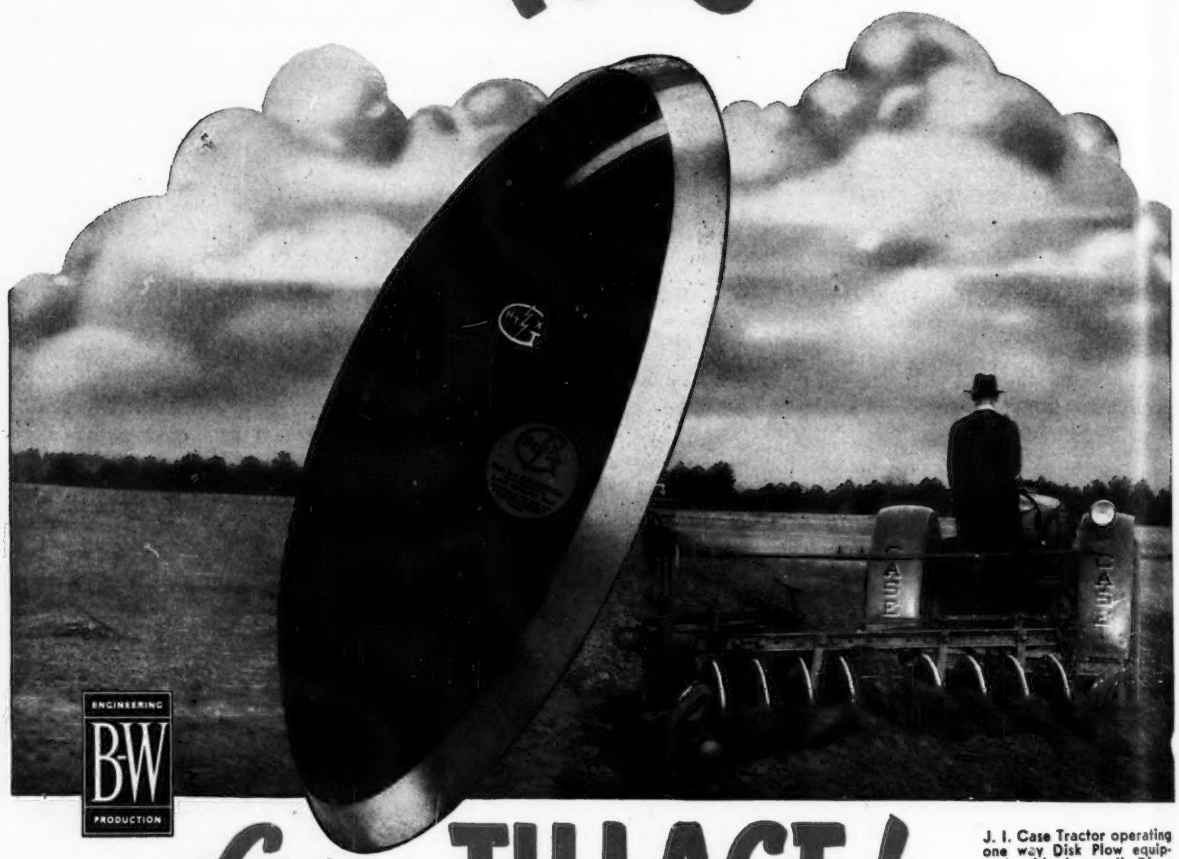
Significantly it has indicated that it aims to do this by securing more adequate financing, personnel, and housing for research, and by encouraging the organization of the research on a project basis favorable to coordination and cooperation of the various technologies concerned.

Also significant is the fact that the Council is to be representative of "all organized groups or companies who have expressed interest in agricultural engineering."

The variety of groups in Ohio which had indicated such interest permitted the designation, at the inception of the Council, of ten major interest groups in rural utilities, farm organizations, farm management, dealers' associations, and manufacturing industries. More may be added as their interest in agricultural engineering research becomes apparent.

(Continued on page 492)

"TOPS"



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AGRICULTURAL ENGINEERING

VOL. 28 NOVEMBER, 1947 NO. 11

Essential Requirements and Basic Structural Types of Farm Ponds

By Robert S. Calkins

MEMBER A.S.A.E.

THE demand for efficient farm ponds in the northeastern states has increased tremendously during the past few years. This demand is still growing and without question will continue to grow. More and more farmers are beginning to appreciate the value of farm reservoirs to meet numerous needs for water on the farm.

The expansion of the farm pond program of various agricultural agencies during these past few years has been so great that it is no longer practical and feasible to have each pondsite examined, surveyed, designed, and construction supervised by a professional engineer. This means that a high percentage of the technical work in preparing plans for and constructing ponds is being done by persons not trained in engineering.

We agricultural engineers in public service, therefore, are faced with a challenge to guide the technical phases of the design and construction of farm ponds. We, as professional engineers, are obligated to provide the indicated technical guidance.

It is hoped that the following discussion on the essential requirements and basic structural types of ponds will, in a measure, answer this challenge. The order of listing the seven essential requirements of farm ponds is not intended to suggest that one requirement is more important than another. All requirements must be met to obtain satisfactory ponds.

1 The pond should meet a definite need, whether it be a need for irrigation, livestock water, spray water, fire protection, fish production, recreation, or a combination of these uses.

2 To supply the pond, there must be a source of water free of barn-lot drainage, acid seepage from mines, undesirable waste from industrial plants, or sewage.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Philadelphia, Pa., June, 1947, as a contribution of the Soil and Water Division.

ROBERT S. CALKINS is zone conservationist (engineer), Northeastern Region, Soil Conservation Service, U. S. Department of Agriculture, Upper Darby, Pa.

3 The pond must have an impervious fill and floor. Some soils have dangerously thin layers of impervious soil. These require special care. Borings and test holes are needed to determine the soil conditions necessary to obtain an impervious fill and floor.

4 The pond must have adequate spillway capacity. A spillway to maintain the elevation of the pond is essential. Ponds through which surface runoff flows require spillways designed for flood runoff. All ponds must have an open spillway to prevent water from overtopping the earth fill in the event that drop inlet or covered spillways become clogged.

5 The flow of water into and through the pond must be regulated to meet the need of water. Inflow to surface water ponds may be regulated by adding to or subtracting from natural watersheds by the use of diversion terraces. Inflow to offstream storage ponds may be regulated by the size and grade of the intake structure.

6 Topography of the pondsite must permit construction at reasonable cost. Flat slopes are preferred to steep slopes. Ponds created by constructing fills across natural watercourses should be limited to locations where the grade of the watercourse is 4 per cent or less, in most cases. Ponds to be constructed on "side hills" should, generally, not be considered on slopes exceeding 8 per cent.

7 The pond should have a drain. The drain may be used to keep the site dry during construction. It will be useful in case maintenance of the earth fill is required. Drains are desirable in ponds to be managed for fish production when species of fish become unbalanced and draining for restocking is required.

There are four distinct types of ponds being used in the northeast. Each basic structural type presents its own design problems. The basic structural type of pond to fit the site and need for water should be selected. Surveys can then be made and designs prepared for the type of pond selected. The four types are (1) surface water ponds, (2) offstream storage ponds, (3) spring-fed ponds, and (4) dugout ponds.

Building a farm pond with a Caterpillar tractor and bulldozer

TABLE 1. DISCHARGE CAPACITY OF VEGETATIVE SPILLWAYS USED IN FARM POND DESIGN AND CONSTRUCTION
(Quantities shown are in cubic feet per second)

Head on crest of spillway in feet h	Length of spillway in feet, L														
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
0.5	2	4	6	8	10	11	13	15	17	19	21	23	25	27	29
0.75	3	7	10	14	17	21	24	28	31	35	38	42	45	47	52
1.00	5	11	16	21	26	32	37	42	47	52	58	63	68	74	79
1.25	7	15	22	29	37	44	52	59	66	74	81	88	96	103	110
1.50	10	19	29	39	48	58	68	78	87	97	107	116	126	136	145
1.75	12	24	37	49	61	73	85	98	110	122	134	146	158	171	183
2.00	15	30	45	60	74	89	104	119	134	149	164	179	194	208	223
2.25	18	36	53	71	89	107	124	142	160	178	195	214	231	244	266
2.50	21	42	62	83	104	124	145	166	187	208	228	249	270	290	311

Computed by furmula $Q = CLH\ 3/2$

in which Q = capacity in cubic feet per second

L = length of spillway in feet

C = A coefficient (h=0.5; C=2.70; h=0.75; C=2.67; h=1.00 to 2.5; C=2:63 — from table 51, page 164, King's Handbook of Hydraulics)

h = head of water on crest of spillway in feet

1 *Surface Water Ponds.* These ponds are so located that all surface runoff from areas above flows through them. It is necessary to have one or more spillways to discharge constant flow as well as flood runoff.

Spillways used to discharge flood runoff include vegetated spillways, reinforced concrete or masonry overfall structures, reinforced concrete flumes, pipes with reinforced concrete risers, and other similar structures. In case of doubt, a competent engineer should be consulted before the type of the structure is determined and specifications prepared, as each structure for discharging flood runoff requires special design. A spillway used in construction of one farm pond should not be used for another unless a detailed investigation indicates the spillway meets the design requirements of the second pond.

Table 1 designates the amount of runoff that will flow through a vegetated spillway at heads varying from 0.5 to 2.5 ft and lengths varying from zero to 30 ft. Where pipe spillways are used with vegetated spillways and the pipe diameter is less than 18 in, capacity of the pipe is usually ignored and the vegetated spillway is designed for the entire flood flow.

Figs. 1 and 2 designate critical features of the vegetated spillway. In most cases the elevation of the base of the vegetative spillway should be 12 in or more higher than the elevation of the normal pond surface. Six inches, however, is the minimum. There are two reasons for this. First, the difference in elevation will prevent the bottom of the spillway from becoming saturated. If the vegetated spillway area is wet, undesirable marsh type vegetation will predominate. Spillways not covered by firm sod may fail. Second, this difference in elevation will permit an appreciable amount of water to be stored above the spillway that controls the pond surface, creating a greater head that will force a larger quantity of water through the spillway that regulates the pond level. Thus the use of the vegetated spillway is minimized. Since it is possible that some farmers will not maintain vegetated spillways properly, the more the use of the vegetated spillway is minimized, the safer the entire pond installation will be.

The entire flow section of the vegetated spillway must be constructed on undisturbed ground. Experience has taught that where *any* portion of the flow section of the vegetated spillway is on filled material, the spillway may fail. Therefore, the critical point in designing and staking the vegetated spillway is the point where the elevation of maximum flow intersects the ground. The end slopes of the vegetated spillway should be 4 to 1 wherever possible and in no case steeper than 2 to 1. Flat slopes on the ends of the vegetated spillway are desirable to facilitate operation of farm machinery in establishing and maintaining grass cover.

In all cases where a vegetated spillway is used to accommodate surface runoff, it will be necessary to have a pipe spillway to handle continuous flow, maintain the level of the pond, or both. Since there will be between 8 and 14 ft of hydraulic pressure on these pipe spillways, high velocities at the discharge will result. Adequate controls of high velocities to dissipate energy must be provided at the discharge ends of pipe spillway structures or serious gullying may result below the pond. Before designing outlet structures to dissipate energy an experienced engineer should be consulted.

The combination of vegetated spillway and pipe spillway is excellent under the right conditions. Vegetated spillways, however, must be planned so flood runoff can flow safely from the spillway elevation to a natural watercourse through vegetated channels designed for velocities of 5 fps (feet per second) or less. Occasionally the basin-type spreader may be used to discharge runoff over a well-sodded convex surface. Where the total cost of the vegetated and pipe spillway combination may be greater than the cost of one reinforced concrete or masonry spillway that would both maintain the pond level and discharge the constant flow and surface runoff, the designer should make estimates of the cost of each alternative and select the one costing the least.

In all surface water ponds, water is temporarily stored above the elevation of the pond surface during the periods when runoff occurs. This temporary storage is illustrated in Fig. 3. In cases where the volume of water temporarily stored between the normal pond surface and the elevation of maximum high water is equal to or greater than the volume of water resulting from one inch of runoff from the contributing watershed, it may be desirable to use a method of flood routing to minimize the size of spillway structure required.

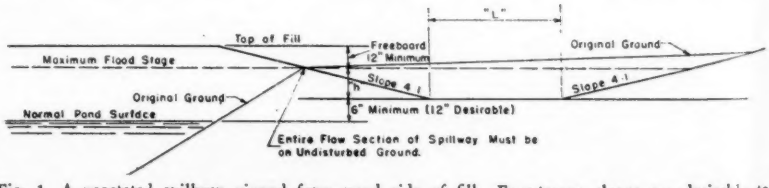


Fig. 1 A vegetated spillway viewed from pond side of fill. Four-to-one slopes are desirable to facilitate mowing, and should be made steeper only when necessary. The maximum slope should not exceed two to one. "L" and "h" may be determined from Table 1

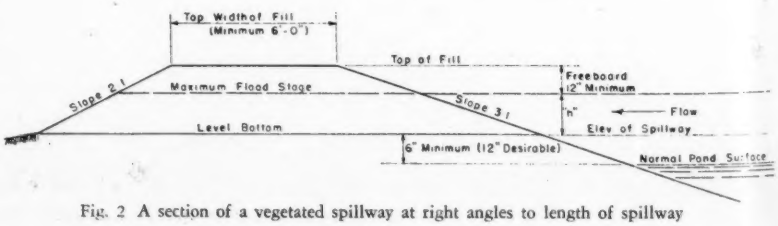


Fig. 2 A section of a vegetated spillway at right angles to length of spillway

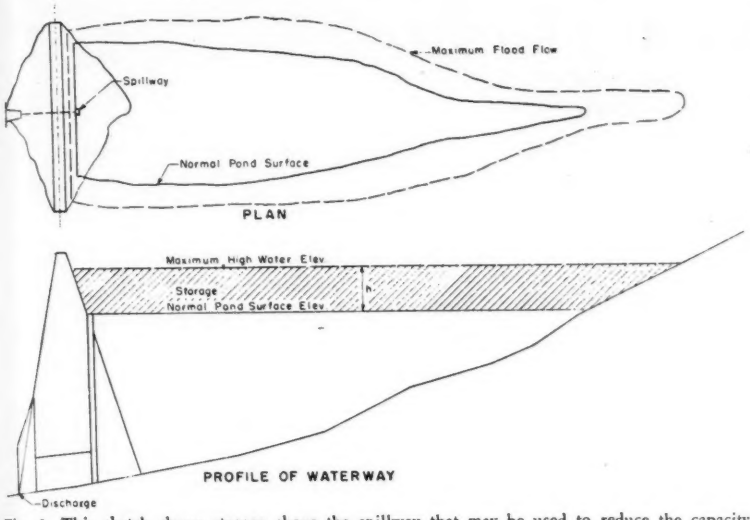


Fig. 3 This sketch shows storage above the spillway that may be used to reduce the capacity of the principal spillway

Most flood routing problems are based on the equation: Inflow = Outflow + Storage. Therefore, it is readily seen that for a given inflow the outflow must decrease when storage increases. Flood-routing problems are, of course, strictly within the province of qualified engineers.

Quite often surface water ponds are needed where there is no possibility of having continuous flow to supply the pond. Surface runoff is the sole source of water. Since the water for these ponds falls from the clouds, they are quite often referred to as "sky ponds."

Sky ponds require considerable design, especially those which must have a dependable supply of water for irrigation or watering livestock. The amount of water available to supply sky ponds, with all other factors being equal, is a function of the watershed area. It then follows that it may be necessary to design the watershed as well as the pond. Natural watersheds can be increased or decreased as may be indicated by use of diversion terraces. Since the design of sky ponds and their watersheds involves a detailed study of precipitation, evaporation and seepage, it is obvious that engineers trained in hydrology should prepare such designs.

2 *Offstream Storage Ponds.* Offstream storage ponds or by-pass ponds, as they are termed in the Northeast, consist of an earth fill and reservoir constructed on a site where soil conditions, topographic conditions, and utilization of water in the pond will be most favorable. Usually the reservoir is adjacent to the flowing stream. Water is supplied through an intake structure to carry water to the reservoir from a flowing stream. This type of pond is adaptable for most uses as flow into the pond can readily be regulated.

If fish production is the major use of the pond, intake may be minimized by permitting water to flow into the pond only when surface evaporation, seepage, or other losses have markedly lowered the pond level. If irrigation is a major use of the pond, inflow can be made as large as necessary, depending upon the flow of the stream, to permit replacement of water that has been pumped out. On many sites this type of pond is less costly than surface water ponds, as elaborate spillways are not needed to discharge surface runoff. There is the additional advantage of minimizing siltation in this type of pond by keeping the intake device closed except when necessary to replace water used on the farm or lost through evaporation or seepage.

Fig. 4 illustrates a typical offstream storage or by-pass pond. This type of pond should be designed so the quantity of earth required to make the fill will balance the quantity of earth removed from the pond area to obtain the desired size of reservoir. The top of the earth fill after settlement occurs should be at least 24 in above the normal pond surface.

The intake structure may be either a pipe or open channel. The elevation of the entrance of the intake pipe, if used, should be at least 24 in higher than the elevation of the surface of the pond. A valve near the point of intake is desirable to regulate inflow. Where pipe intakes are used, the pipe must be below the frost line at all points. A low porous dam in the stream, 18 to 24 in high, near the point of intake to create a head of water and force water into the intake pipe may be desirable. Intake pipes usually discharge on the bottom of the pond and have a concrete slab at least 6 in thick and approximately 3 ft square at the outlet end of the intake pipe to minimize erosion. Concrete collars at least 3 ft square around the intake pipe whenever it passes through an earth fill are needed to avoid seepage from the pond caused by back pressure. The size of intake pipes depends on the need for water. A 4-in minimum diameter is suggested.

If an open channel is used, it must be designed to provide velocities of 3 fps or less in the channel, sufficient quantities of water, and a gate to regulate the flow of water into the pond.

By-pass ponds should be planned so that there will be little or no amount of surface water flowing through the pond. In some locations, the natural topography is such that surface runoff is not a problem. In other locations, it is necessary to construct diversion terraces above the ponds to remove all surface flow.

An adequate spillway for the by-pass pond is illustrated in Fig. 5. The grade of the pond bottom must be designed so the pond can be drained which means that the elevation of the pond bottom must be higher than the elevation of the stream at the point where the pipe spillway discharges.

3 *Spring-fed Ponds.* The spring-fed pond consists of a reservoir constructed in an area adjacent to and lower than a continuously flowing spring which serves as the only source

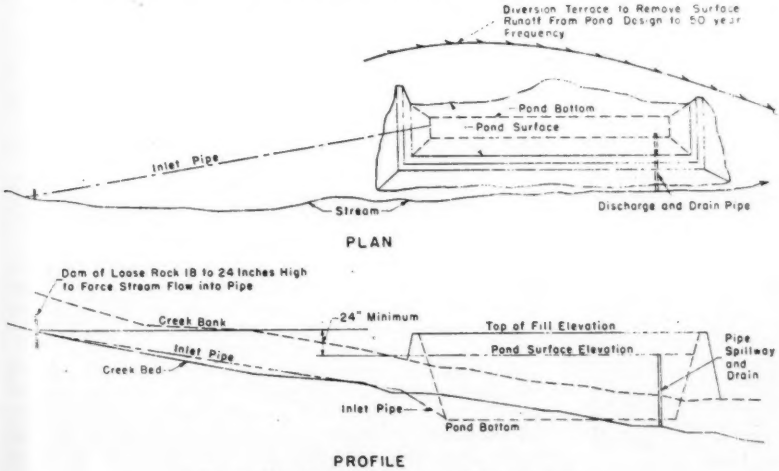


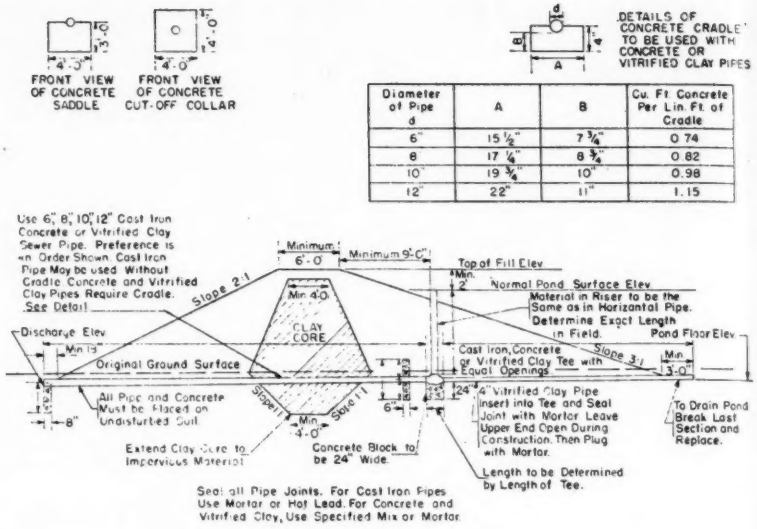
Fig. 4 This sketch shows a typical by-pass pond

of water for the pond. Since a continuously flowing spring will usually maintain water in a pond, it is desirable to eliminate surface runoff from the pond by means of diversion terraces. A typical spring-fed pond with surface water diverted is shown in Fig. 6.

The top of the fill should be least 24 in above the normal pond surface. The amount of earth required for fill should equal the amount removed to obtain reservoir capacity to obtain the most economical movement of earth.

The pipe spillway in Fig. 5 is also suitable for use in spring-fed ponds. The only design requirement for pipe spillways in spring-fed ponds is that the pipe be large enough to handle the maximum flow from the spring. The use of any type of vegetated spillway to discharge constant flow in spring-fed ponds is not recommended.

Spring-fed ponds often take considerable time for the spring flow to fill the reservoir, are economical to construct, and are readily adapted for fish management and livestock watering. In locations where it is desirable to have the pond surface above the elevation of the spring supplying water to the pond, precautions must be taken and should not be considered unless the designer is certain that it can be done. To make sure that it is possible to submerge a spring, construct a small, temporary dike around the spring to the height of the normal pond surface of the proposed pond, or cap the spring and place a section of pipe on top of the cap so that water from the spring will be forced into the pipe. If water will not flow over the top of the temporary dike, it is obvious that the pond will not build up to the desired elevation. The elevation to which water rises in the pipe will indicate the maximum elevation of the normal pond surface.


FRONT VIEW OF CONCRETE SADDLE
FRONT VIEW OF CONCRETE CUT-OFF COLLAR
DETAILS OF CONCRETE CRADLE TO BE USED WITH CONCRETE OR VITRIFIED CLAY PIPES
Use 6", 8", 10", 12" Cast Iron Concrete or Vitrified Clay Sewer Pipe. Preference is on Order Shown. Cast Iron Pipe May be used Without Cradle. Concrete and Vitrified Clay Pipes Require Cradle. See Detail
Slope 2:1
Minimum 6'-0"
Minimum 9'-0"
Top of Fill Elev.
Min. 2'
Normal Pond Surface Elev.
Material in Riser to be the Same as in Horizontal Pipe. Determine Exact Length in Field.
Pond Floor Elev.
Discharge Elev.
Min. 1'-3"
Original Ground Surface
CLAY CORE
Min. 4'-0"
Cast Iron, Concrete or Vitrified Clay Tee with Equal Openings
Slope 3:1
Min. 3'-0"
All Pipe and Concrete Must be Placed on Undisturbed Soil
Slope 1:1
Min. 4'-0"
Extend Clay Core to Impervious Material
Concrete Block to be 24" Wide
4" Vitrified Clay Pipe Insert into Tee and Seal Joint with Mortar Leave Upper End Open During Construction. Then Plug with Mortar.
To Drain Pond Break Last Section and Replace.
Length to be Determined by Length of Tee.
Seal all Pipe Joints. For Cast Iron Pipes Use Mortar or Hot Lead. For Concrete and Vitrified Clay, Use Specified Mix or Mortar.

Diameter of Pipe d	A	B	Cu. Ft. Concrete Per Lin. Ft. of Cradle
6"	15 1/2"	7 3/4"	0.74
8"	17 1/4"	8 5/8"	0.82
10"	19 3/4"	10"	0.98
12"	22"	11"	1.15

Fig. 5 Details of a spillway for the by-pass pond

4 *Dugout Ponds.* Fig. 7 illustrates a typical dugout pond. These ponds are practical in fields where the slope is 4 per cent or less. Subsurface flow resulting from a high water table is used to supply the pond. The dugout pond requires a minimum of design as no portion of the pond depends on a constructed fill to hold water in the reservoir. Dugout ponds are useful for watering livestock, obtaining irrigation and spray water, and producing fish.

The discussion in this paper on essential requirements of farm ponds and the basic structural types of ponds may serve to guide persons who are not professional engineers in selecting sites for farm ponds and indicate the design requirements. If this purpose has been accomplished, more farmers will be assured of having adequate and dependable supplies of usable water in their reservoirs.

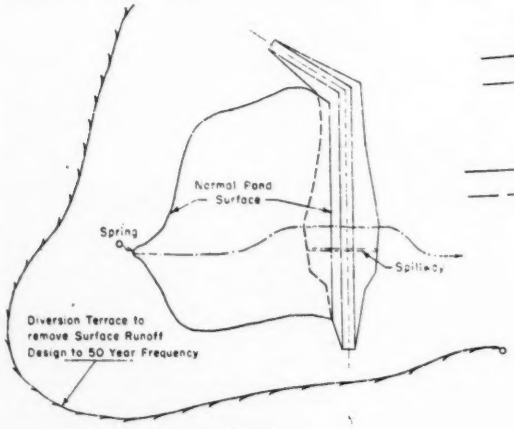


Fig. 6 This sketch shows a typical spring-fed pond with surface runoff removed by a diversion terrace

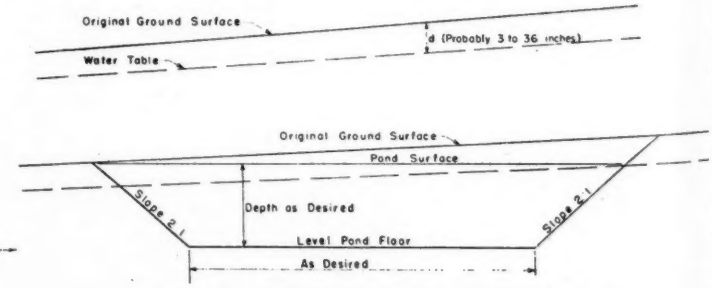


Fig. 7 A typical dugout pond supplied by subsurface water. The top sketch shows the relation of ground to water table. The bottom sketch shows the relation of the pond to ground surface and water table.

Obtaining Support for Research

(Continued from page 435)

In addition to studying and presenting the need for public and private funds for agricultural engineering research, the Council is to serve as an advisory body to the agricultural engineering department of Ohio State University and the Ohio Experiment Station on the use of funds for research.

Organization to secure and administer support for research is developing as an art prerequisite to the actual conduct of research. Some study of the art, reflecting influences of form of organization and manner of procedure on support obtained by various groups, might help all groups interested in gaining further support for agricultural engineering research.

An Experimental Mole Ditcher

By E. W. Schroeder
MEMBER A.S.A.E.

MUCH land could be improved by better drainage. Some of this land is in the form of wet spots and imperfectly drained soils on established farms. These soils remain wet so late in the spring that cropping may be prevented and the choice of crops that can be grown is often limited. The slopes are generally slight, and if drained could be farmed rather intensively without excessive soil losses due to erosion. More intensive use of these soils would encourage the use of soil conserving crops on the steeper upland slopes. Wet spots in fields add to the cost of production, especially when the farm is mechanized. To relieve these poor drainage conditions by the use of tile involves high labor and material costs. Some of the land that might be improved by mechanical drainage methods is of insufficient value to warrant the expense of complete tile installations.

Work done in England[1]* and also in this country by the U. S. Department of Agriculture suggested that poorly drained land in Pennsylvania might be improved by mole drains or some other inexpensive method of drainage.

The initial phase of the research consisted of an investigation to determine which of the wet clay soils in the state could be improved by mole drainage in its present state of development. On the basis of the clay content, slope and outlet possibilities, six soil types covering areas of 50,000 acres each offered possibilities of being improved by mole drainage. To install the experimental drains a light-weight machine on skids[2] was designed and built.

Design of the Machine. To keep the machine light it was designed on the basis of an allowable unit fiber stress of 25,000 psi. Light-weight channels, 11.5 lb per foot, 8x2¼ in were used for the skids. To strengthen the channels where the bending moment would have caused a stress greater than 20,000 psi and to provide rigidity, a ⅞-in plate 3½ in wide was welded in place between the channels at A, Fig. 1. This weld in addition to ⅞-in spacers welded between the channels at points B and C, holds the channels together and provides clearance for the ¾ x 7-in steel plate used for the beam. One-inch pins P and G prevent the beam from turning between the two 10-in vertical channels. To remove the chisel and ball from the ground, pins P and G are removed, the machine pulled forward allowing the beam to pivot around H, the depth pin, until the chisel clears the ground. One of the pins laid across the supports at I holds the chisel out of the ground. Pin H should be located high enough so that the top of the pivoting beam clears the rolling coulter. By removing pin H the beam can be detached for loading the machine, the total weight being only 450 lb. Two men are easily able to load it on a light pickup truck.

As a basis for calculations, the center of resistance R, Fig. 1, was taken to be the leading edge of the chisel point. There were several reasons for this assumption which later field trials proved to be correct. The chisel point does the major work on the soil, shattering and loosening it ahead of the beam and shell. A calculation using this point as a center of resistance also gives the maximum bending moment for the beam as well as for the skids. In case a stone is encountered at the chisel point, that point momentarily becomes the center of resistance. With no information available on soil forces on this type of machine, a pulling force, F, for making calculations, was selected on the basis of the drawbar pull of the size tractor required for pulling the machine. Previous experience with subsoiling and soil conditions in areas to be drained, indicated that the maximum pull of a 5-ton, 50-hp truck-type tractor would be required.

Locating the Center of Resistance. When a machine of this type is pulled with a free linkage between the tractor and the machine, the points D, E, and R fall on a straight line. The center of resistance was determined by pulling the machine with several different tractor drawbar heights and adjusting the height of hitch on the machine each time until the skids ran parallel to and just touched the ground in front. Since each of these lines of pull passed through the center of resistance, their point of intersection located R. The location of R naturally varies with soil conditions, being nearer the leading edge of the chisel point in soils with tough clay subsoils. When operating in muck soils the center of resistance would probably be nearer the surface.

Location of Hitch Point. Since a machine of this type is pulled directly behind the tractor, location of the horizontal hitch point is not a problem. Location of the vertical hitch point is of utmost importance for securing penetration and satisfactory performance. To keep the machine upright it was hitched with a short free link so that the tractor prevented the machine from tipping sideways. A straight line from the tractor drawbar hitch point, D, Fig. 1, to the center of resistance, R, locates the height of hitch, E, on the machine. If the maximum and minimum depths at which the machine is to operate are known, the range of the height of hitch on the machine can be determined. It is advisable to make provision

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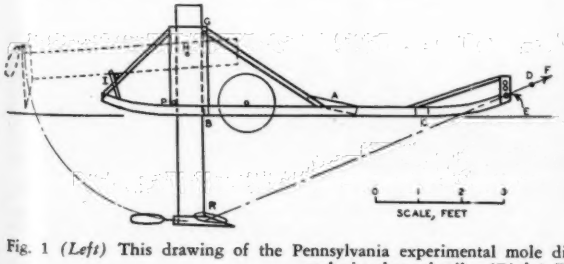
*Superscript numbers refer to appended references.



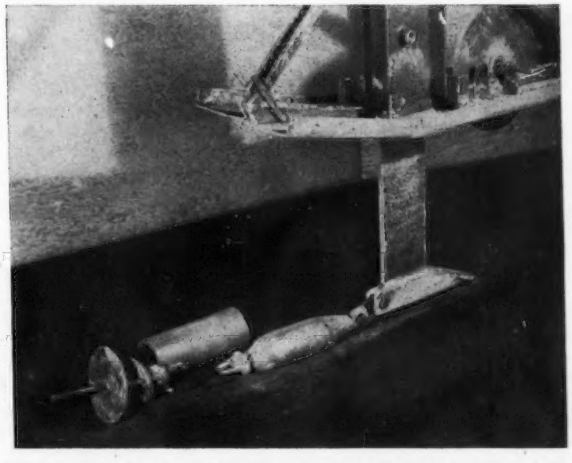


Fig. 1 *(Left)* This drawing of the Pennsylvania experimental mole ditcher shows the location of the center of resistance when operating the mole in clay subsoils *(Right)* The working parts of the mole ditcher

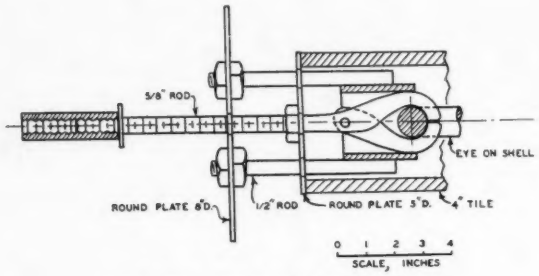


Fig. 2 Detail drawing of the outlet tile setter

in the height of hitch to compensate for variations in height of tractor drawbars, providing various tractors are to be used for pulling the machine.

There is a tendency to locate the hitch too high on this type of machine and other deep-tillage tools. When this machine operates 30 in deep, pulled by a tractor drawbar 9 in high, the hitch point on the machine is only 5 in above the ground. A longer link between the tractor and the machine would make the hitch still lower. The adjustment of the hitch and the effect of improper hitching on the operation of the equipment is discussed under "Operation of the Machine".

Protecting Drain Outlets. The cost of the initial investigations was kept at a minimum by using existing ditches for outlets. An inexpensive and convenient way of using a ditch is to start the drain at the ditch, pulling the machine upgrade, thus emptying each drain directly into the ditch. Spacing the experimental drains 9, 15, and 20 ft apart made it necessary to protect numerous outlets. One rain may deterioriate unprotected mole drain outlets in an earth ditch bank so that the entire drain ceases to function. A tile laid at the end of each drain protects the outlet, but time and labor for doing this is expensive. The tiles must be laid with extreme care to prevent breaking the wall of the earth drain and to secure a good bond between the earth and the tile, or the outflowing water will undermine or flow to one side of the tile.

To protect each drain outlet and at the same time secure a good bond between the soil and the tile, a device was made so that the tractor could be used for pulling the tile into place in the outlet of the drain. To stop the tractor each time to release the tile when it was pulled in far enough would have been time consuming and it would also have been difficult to stop the tractor at exactly the right time. To overcome these difficulties a tile setter, Fig. 2, was designed so that tile was automatically released when the outlet edge was flush with the ditch bank. The forming shell was the same size as the inside diameter of the tile, 4 in. Hence, the wall of the tile as it was pulled into the drain compressed the soil about its leading edge forming an excellent bond between the tile and the soil.

Operation of the Machine. The adjustment of the height of hitch was most important for obtaining satisfactory operation of the machine. It is necessary that this adjustment be made in the field since the center of resistance varies with the depth of the drains and to some extent with the soil conditions. Proper height of ditch is indicated when the front part of the skids are just touching the ground. A hitch that is too high places excess pressure on the front part of the skid causing increased draft. A high hitch also tends to raise the back of the machine, and in extreme cases the machine will ride on the front of the skids with the rear of the skids completely off the ground. Such conditions of operation tip the top of the beam forward, changing the relative position of the chisel point and the hitch point of the shell. The drain thus formed is above the bottom of the cut made by the chisel point leaving fractured and loose soil for the channel bottom. A high hitch will also tend to form an elliptical rather than a cylindrical drain.

Most of the experimental drains were installed by pulling upgrade from an outlet ditch. However, it was not necessary to start the machine in a ditch to get it into the ground. When mole drains were emptied into a porous fill above a tile drain, the machine was placed into the ground for pulling it across the tile outlet from the opposite side of the drains as follows: Pin at I, Fig. 1, was removed, allowing the chisel point on the beam to rest on the ground. Since the machine could not tip sideways the tractor was backed up until the beam jackknifed into position. In so doing the back of the machine was raised equal to the length of the beam below the skids. When the machine was pulled forward, the chisel and shell penetrated to full depth in 6 to 10 ft of forward pull.

Practically all of the wet soils in which mole drains were installed were on slopes steep enough so the drains could be installed on uniform grade by using slightly curved lines. Grades of 3 or 4 in per 100 ft were used. A few installations were made with 5 in drop per 100 ft.

Plaster casts taken immediately after they were installed gave valuable information for improving the design of the equipment. After several corrections in design of the chisel point the casts showed that smooth cylindrical channels were being formed, and that the bottoms of the mole channels were on firm, undisturbed soil (Fig. 3). The casts also showed that due to rebound or expansion of the soil, a 4-in shell formed a 3½-in drain.

Preliminary Results. Over 33,000 ft of mole drains were installed in six different soil types in four counties of Pennsylvania. Plaster casts and numerous checks showed the drains to be well formed with the equipment designed. The outlets were also protected as described in the fore part of this paper. The drains were installed in late fall when the subsoil was plastic. In some cases, the drains began flowing 6 to 10 min after being made and continued to flow for several months; however, by spring many of the drains were filled. Examination of cross sections of the drains in the fall and again the following spring showed that most of the drains had failed. In the fall cross sections, the drains were 3½ in in diameter, well formed in mottled soil. In the spring cross sections, the drains were a cylindrical mass of loose soil with no mottling, 8 to 10 in in diameter. From the above it was concluded that the failure was due to slacking or to chemical and physical changes in the soil caused by expo- *(Continued on page 502)*

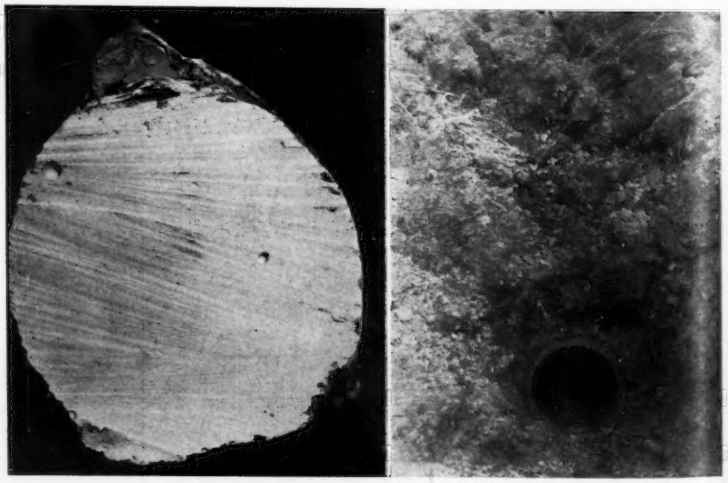


Fig. 3 *(Left)* Cross section of a plaster cast of a mole drain. These plaster casts provided information for improving the design of the equipment and also served as a check on drain openings in different soil types • Fig. 4 *(Right)* This shows a tile pulled into a mole drain with a tile setter for protecting the outlet. Note soil fractures above the tile which facilitates water entering the drain

Opportunities for Human Advancement through Agricultural Engineering

By R. E. Moore
MEMBER A.S.A.E.

WE HAVE been conditioned by reports of conferences and official and unofficial exchanges between governments to accept the fact that *all* the world today is seeking the assistance of the United States. Most of the publicity given to this seeking concerns physical and economic assistance, such as food, industrial goods, clothing, and dollar loans. This situation is not new. It followed World War I, and is an aftermath of World War II. In addition to physical assistance, most peoples and governments of the world are seeking scientific and technological assistance from the United States—the experience in the brains of our scientists and technicians is a commodity which they regard as necessary to their economic progress. This request for technical assistance also is not new. Through the years United States science and technology have been made available to some extent to all peoples, especially the experience and competence which other peoples consider to be America's greatest skill and America's great achievement, and which we group under the heading of "engineering." However, the universality of the belief that science and technology is a prerequisite to an improvement in their over-all economy, *is* new — is a *new fact* which has significant implications affecting the responsibility of the profession of agricultural engineering and of the institutions which prepare agricultural engineers.

Considering the demands which the United States' standard of living makes upon our natural and human resources, it is fortunate that other peoples and other governments are emphasizing the loan of technology and science in their requests for assistance since human experience and human competence is perhaps the only commodity that we can make available to needy peoples and, by so doing, increase the supply remaining for our own use.

The following discussion of (1) the opportunities for agricultural engineering in tropical agriculture, and (2) the competence the engineer must possess to take advantage of these opportunities, is pertinent to an understanding of the contribution which agricultural engineering can make to the economic and security interests of the United States and to world stability and progress. To a considerable extent these considerations are also significant with respect to temperate zone agriculture.

A great proportion of the people of the world live within the tropics. In the tropical regions, from 60 to 85 per cent of the population is engaged in agricultural pursuits. In these regions, improved planting materials and improved cultural practices are not used as extensively as in the rest of the world generally. This is especially true if comparisons are made between tropical agriculture and the agriculture of the United States. A reduction in the great disparity between the efficiency of production and distribution of the United States and that of these regions will contribute to the economic and *security interests* of the United States and to world peace.

Not only is the United States a great producer of agricultural commodities, but also a great importer of agricultural commodities produced in the tropics. The importation into the United States of tropical agricultural commodities is more than one billion dollars annually and represents between 25 and 30 per cent of all imports for consumption. Our trade with tropical countries is dependent to a great extent upon their ability to produce materials for United States consumption, thereby strengthening the economy of these regions and increasing their capacity to import products of United States industry and agriculture.

The Army and Navy Munitions Board, in response to legislative direction by our Congress, maintains a current list of strategic and critical materials. The majority of the agricultural commodities imported into the United States, such as rubber, vegetable fibres, insecticides, oils, and many others, are included in this list. These materials are required for our peacetime economy and are essential in a war emergency. Their procurement in adequate quantity, quality, and time is uncertain to the extent that prior provision for supply, such as stockpiling, is required to maintain the security of the United States. The resources of the agricultural engineer are required to establish living sources of supply of these commodities within our geographical area of maximum security.

Of the environmental forces affecting economic development, malnutrition, human diseases, and intestinal parasites, rather than oppressive climates, are largely responsible for the retarded development of tropic regions. This is especially true in the Western Hemisphere. The experience gained from such areas as the Panama Canal Zone, the scattered properties of the United Fruit Company in Middle America, and from other areas, shows that people *can* live healthfully and work vigorously in the tropics when furnished adequate food, potable water, sewage disposal, and protection from insects carrying communicable diseases.

Some of the finest soils in the American tropics remain uncultivated because of unhealthful conditions. Vast areas on the Pacific coast of Central and South America lie in idleness because of the shortage of laborers. This shortage is due primarily to the presence of malaria, typhoid fewer, and intestinal parasites, which debilitate the people already in these regions and dissuade others from coming in. The establishment of healthful living conditions is a problem on which agricultural engineers, sanitary engineers, medical scientists, and social scientists must put their heads together if such regions are to contribute fully to the welfare of mankind.

The low standard of living prevalent in the tropics is due largely to low productivity. Crops are produced using hand tools rather than mechanized implements. This type of machete agriculture is practiced by most of the subsistence farmers in the American tropics and it is common even on large haciendas producing such export crops as coffee, cacao, cotton, and sugar. Labor requirement studies made in 1944 in tropical America show that 35 man-days of labor were required to produce an acre of corn. An average family of father, mother, and three children were considered self-sufficient if they could keep seven acres in cultivation. To prepare an acre of seedbed with a hoe rather than with an ox or tractor-drawn plow required an average of 12 man-days. To weed an acre of corn with a machete took 3 man-days. To harvest wheat with a sickle and tie bundles by hand consumed 8 man-days per acre. At this rate of productivity a man can scarcely afford to raise grain or tame hay for livestock. His own needs come first. Without animals he has no manure and, living on a subsistence level, he cannot afford commercial fertilizers. Consequently production per unit area as well as production per man-day are low.

Greater mechanization of farm operations will undoubtedly increase the yield per man, but, to promote mechanization, all factors which operate to retard it must be dealt with, the human as well as the natural and physical.

Religious beliefs and superstitions sometimes deter the use of machinery. Among relatively primitive groups, there are often elaborate rituals with the planting, cultivating, and harvesting of crops. Any deviations from these well-crystallized patterns, such as the introduction of machinery or other modern methods of cultivation, are opposed by a moral restraint. Overcoming these superstitions and attitudes is sometimes more difficult in the introduction of machinery than are the physical difficulties of soil, topography, and climate.

This is an address delivered at the Annual Meeting of the American Society of Agricultural Engineers at Philadelphia, Pa., June, 1947.

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Agricultural mechanization is affected in many tropical regions by the density of population. In India, Burma, Siam, and in certain areas of the Philippines and of the Western Hemisphere, the number of people in relation to the natural resources and their present state of development is so great that mechanization of their agriculture will give rise to serious social and economic problems. Such heavy population inevitably results in the subdivision of lands into small parcels and makes high per capita production difficult. If mechanization of agriculture takes place in such regions, people are displaced because one machine can do the work of many people. Unless employment is found in industry or in other agricultural regions for such displaced persons, they become unemployed and willing to work for small wages which in turn makes hand labor so cheap that it becomes uneconomical to operate machinery. This necessitates a return to hand methods of production. The break in this cycle from hand labor through mechanization to hand labor, if accomplished, will result from the skillfully engineered application of the competence of economists, industrialists, engineers, and sociologists.

A friend of mine from Arkansas expressed great confidence in the ingenuity of agricultural engineers the other day. He said, "You know, engineers can and will devise a machine to do any farm job that needs doing—'cepting' maybe pickin' strawberries!" He further said, "For us in the South, it's going to be more difficult to learn to live with machines than to learn to operate them."

A DETERRENT TO MECHANIZATION IN THE TROPICS

A deterrent to mechanization in many tropical regions is the lack of understanding on the part of the people of how to select, operate, and maintain machinery at a high level of efficiency. To meet all of the machine repairs and difficulties that arise in the normal operation of farm machinery requires considerable training and understanding of the equipment. Most tropical regions lack a sufficient number of people with this training and understanding.

The demand for American machinery depends upon the farmer's ability to buy, which in turn is dependent upon the efficient use of the equipment he already has. The best promotion we can make for our equipment abroad is to make sure that the equipment we sell fits the job for which it is to be used; to service the machinery in order that it may be maintained at a high level of efficiency; and to insure that spare parts and replacements are promptly obtainable. If these conditions are met, the farmer with his machine will make sufficient money to buy more machinery. They have not been met, in too many cases, abroad. Many practically new implements are lying idle throughout the tropics, broken and unused because they were attached to too heavy a tractor; on the other hand, many new implements are unused because the farmer had insufficient power. I have seen practically new tractors standing idle for months awaiting the arrival of simple repair parts. Partly because of these situations, many acres appropriate for mechanization, once hand mechanized, have since returned to hand tillage. Service dealers, so necessary to the agriculture of the United States, are much more essential to the mechanization of agriculture in tropic regions. Assistance to farmers and training schools for farm machine operators are necessary to economic mechanization of tropical areas.

The practicable solution of problems related to water use, conservation, and disposal, is a prerequisite to agrarian improvement in most of the tropical regions of the world. Although irrigation is practiced to a greater or lesser extent in all tropical countries, its expansion is needed especially in the development of diversions from small streams, small-scale diversions from large streams, and in pumping from streams and underground supplies. One of the chief deterrents to irrigation development in most of these regions is the lack of community organization and solidarity. Incomes are sometimes so low that few investments over and above the necessities for living are made. The educational level of the people with respect to effective methods of agricultural production is often inadequate, rendering it difficult to organize them into a driving force that will lead to the construction and maintenance of efficient irrigation systems. In some tropical regions otherwise well-planned and constructed irrigation systems have been ineffective because of the reluctance of the people to carry the economic and work responsibilites required for the system's maintenance and operation.

Since irrigation is primarily a community endeavor, the successful project most frequently results from the close collaboration of the engineer and other agriculturists with medical and sanitation specialists and with men competent in the fields of economics and sociology.

The advancement of agriculture in the tropics requires improved facilities for the provision of potable water to the individual farm as well as to rural villages. Water is generally used from streams, springs, etc. In the wet season, such sources are polluted by surface drainage, and in the dry season they frequently fail. Women carrying a can of water on their heads—frequently for miles—are a common sight in the dry season. Very little has been done to develop underground water supplies.

The engineer can provide potable water supplies if rural peoples are stimulated to support their development by practical adult and youth education which takes into account the attitudes and living habits of the rural people.

Water in the form of excessive humidity presents a series of grave problems of economic and social import. In the wet season, grain spoils; seed for the next crop molds; clothes mildew. Much work can profitably be done in grain drying and storage, also in the drying of green forage to carry cattle through the long dry season. The holding of grain from a season of high production for use during periods of non-production has important implications in respect to the use the farmer will make of his land, in the seasonal price fluctuation of commodities, in the cost and level of living, in the nutrition for the whole community, and in the community's participation in national and international trade. The engineer should gain an understanding of these implications and his designs should take them into account.

Farm structures of all types are needed for the high efficiency of man and farm animals and also for the storage and on-the-farm processing of agricultural production. The conservation of soil presents many pressing problems. Agricultural sanitation, including the use of insecticides, fungicides, and herbicides, must be advanced. Most of the problems require the resources of the educator, the economist, the sociologist, as well as the entomologist, pathologist, agronomist, and agricultural engineer.

A CONCEPT OF CONTENT AND OBJECTIVE OF ENGINEERING

I have presented only *some* of the important problems retarding the advancement of tropical agriculture. There are many others which might be listed but these serve to indicate the opportunities for agricultural engineering, and also the tools which the engineer must have to tackle these problems.

Engineers have formed definitions which set forth adequately the content and objectives of engineering. I defer to these definitions although I have not consciously referred to any of them in formulating the following conception of the content and objective of engineering, which assumes that essentially engineering is made up of *the results of science, physical materials, and man;* and that the engineer deals with the application of science to man and materials for the benefit of mankind. We recall that Stephen Van Rensselaer, called father of engineering by some, founded the Rensselaer Polytechnic Institute, to "apply science to the common purposes of life."

Because of the increased responsibilities of the agricultural engineer, a continuing study of our engineering curriculums should be maintained to insure that engineering students grasp the principles which will advance the *balanced* use of *all* the resources of science and will provide the necessary understanding of man and his institutions.

A leading American industrial executive has said: "I can speak for some 12,000 engineers I have known in company relations. There have been few difficulties because of lack of technical or professional skill. In almost every case of failure, the problem has been one of human relations."

The agricultural engineer is a user of facts. He should not disperse his efforts to acquire professional *excellence* in the physical and natural sciences or in the social sciences. He should be given course work, how- *(Continued on page 499)*

The Field Forage Harvester

By Paul A. Whisler
MEMBER A.S.A.E.

THE frequently repeated statement that the hay or forage crop is the least mechanized crop left for the farmer to sweat over is trite. But it is still basically true. Much work has been done in recent years to conquer this latest mechanical frontier, but to date, with a few notable exceptions, most of the mechanical developments have been aimed primarily at reducing time and labor with not too much concern about over-all efficiency. We still go on at great effort "scientifically" tilling the land, applying fertilizer, selecting and planting seed, and then haphazardly mow down the grass crop and drag it into the barn, leaving 75 to 90 per cent of the vitamin A and 25 to 35 per cent of the digestible nutrients unused in the field. On far too many farms instead of the cow getting her "Wheaties" for breakfast, she gets only the cardboard box they came in.

The forage crop is the one most indispensable source of human food. Without it humanity would gradually starve to death. Conversely, any general reduction of the present high losses in utilizing this crop will directly improve the world food supply.

Because the forage crop is not generally considered a cash crop by farmers, it has never been given its proper evaluation by them. Consequently, the 25 to 35 per cent yearly loss has not caused much worry. Our best animal nutritional authorities, however, estimate that these losses to the farmers of the United States through weathering and improper handling methods amount to $500 million annually in forage feed value. Any saving the farmer can attain through reducing these losses will show up directly as increased profit in livestock and livestock products. For northern farmers the present trend of increased competition from southern areas where livestock can be pastured all year round will likely soon make it necessary for them to increase efficiency through reducing these losses.

Requirements and Problems. With these thoughts in mind the following basic requirements or standards that new forage handling equipment and practices must meet are proposed:

1 First, and most important, such equipment and practices must reduce the losses in food value of the crop from the field to the cow.
2 They should encourage an increase in total nutrient yield per acre per year.
3 They should reduce labor from the standpoint of both total man-hours and also physical exertion.
4 They must be economically practical.

W. H. Hosterman of the USDA estimates that 89 per cent of the hay grown in the United States is fed to livestock on the farm where produced. In this discussion the field of consideration is limited to the farms that fall into this category; that is, to those farms on which the forage crop is merchandized through livestock and livestock products.

On these farms at present the conversion from crop to livestock is done in three general ways: (1) By direct pasturing or soiling, (2) by use of dry hay, either field cured or barn cured, and (3) by use of grass or legume silage.

Each of these systems has some definite advantages, but today on most farms they are carried out in a random unorganized manner depending mostly on local custom, individual habits, and to some extent on machinery available. It follows that the ideal forage harvesting equipment, while meeting the four basic requirements, should not only be useable in all of these general systems, but should tie them together into a definite, yet flexible plan that enables the farmer to take advantage of variation in weather, markets, and cropland and labor available to get the most out of his farm in the form of livestock and livestock products, and in the end the highest cash profit.

The Answer. The forage harvester does just this. Originally the forage harvester was conceived to chop dry hay in the field, but later it was applied to the making of grass silage. It is primarily through the increased use of grass silage that it fulfills the requirements we have set up.

As is generally known the losses encountered in harvesting forage fall into four main categories: (1) loss of nutrients due to improper cutting time, (2) loss due to weathering, (3) physical loss from handling, and (4) loss during storage.

It has long been conceded that harvesting forage as silage reduces the total nutrient losses in the original material over the losses encountered in any other system. Use of the forage harvester and grass silage is the only system that makes it possible to cut the crop at exactly the right stage of growth regardless of the weather. There are no field weathering losses because only a few minutes elapse between the cutting of the standing crop and placing it in storage. Handling losses are negligible because cutting, chopping, and loading are done in one simultaneous operation without the stalks touching the ground. When crops are down and tangled, the forage harvester sickle does a better job of cutting than a mower because it has a reel to keep the sickle wiped clean.

Allis-Chalmers forage harvester in use for direct harvesting of an alfalfa-wheat mixture for grass silage

Most experimental reports indicate that the losses of digestible nutrients in storage due to top and side spoilage, leakage, and fermentation are slightly higher for silage than the storage losses for dry hay. Even with this greater storage loss, however, the total losses of nutrients from the growing crop to the cow through silage should never be more than 15 per cent on a dry basis and with proper care in handling can be reduced to 5 per cent or less. This compares with an average loss of about 20 per cent in barn-cured hay and 25 to 35 per cent in field-cured hay. Often losses in dry hay

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Two views of an Allis-Chalmers forage harvester in use. *Left:* Harvesting corn for silage with a row-crop attachment • *Right:* Picking up and chopping wilted alfalfa from the windrow for barn curing

are much higher than these figures due to unfavorable weather.

When it comes to vitamins, ensiling is the only way to store an appreciable amount of vitamin A for any useful length of time. In dry hay the carotene (pro-vitamin A) content continues to decrease rapidly with every month of storage, but in silage, after the initial loss during fermentation, the carotene content is preserved much longer. Starting with the average of 200 to 300 units (micrograms of carotene per gram of dry matter) in the standing crop, the best barn-cured hay will do well to have 10 to 15 units left after six months of storage. Field-cured hay will drop to from 0 to 15 units, but the same crop ensiled will usually have well over 100 units left even after a year of storage.

At the same time that the forage harvester through grass silage meets the first requirements — reduced losses — it automatically fulfills the second requirement, namely, increased nutrient yield per acre per year. When the first cutting of most forage crops is removed early and quickly, as it should be for greatest food content, the plants gain the advantage of late spring rains to produce a better and earlier second crop. Often this even makes possible an extra cutting later in the season. In any event the total seasonal yield is increased over what it would be if the first crop were allowed to remain on the field two or three weeks longer waiting for good dry hay weather.

To gain the advantages set forth above, it is necessary to handle and store more total tons of material than when dry hay systems are used. Due to the simplification of the handling procedures, however, this can actually be done with fewer man-hours and much easier man-hours per ton of digestible dry material stored than are required in conventional dry-haying methods. Some tests have shown a slightly lower man-hour per ton of dry matter requirement for the new high-speed one-man balers. But the one-man baler cannot compete in the matter of least physical exertion. Even with the best of bale loaders and conveyors the bales must at some time be manually lifted and carried while storing. The forage harvester, in connection with the new automatic unloading wagons rapidly being developed, makes it possible to move the forage crop from the field to the silo without any manual lifting or handling.

With this equipment, even though a three or four-man crew is needed for continuous operation, a farmer and his boy, or girl, or, if necessary, the farmer himself can harvest the forage crop from the ordinary 150 to 200 acre livestock farm sufficiently fast to keep the over-all loss of food below that of conventional methods. He can also do this without heavy manual labor. Thus, the third requirement above has been met satisfactorily by the forage harvester and grass silage.

It should be noted here that to meet these requirements satisfactorily, it is necessary that the forage harvester be equipped with its own sickle and be able to cut the standing crops direct as well as be able to pick up the crop from a windrow. The full saving in digestible nutrients, vitamins, man-hours and over-all efficiency of harvesting simply cannot be attained if the crop is first mowed, then raked, then picked up and chopped.

This statement is in disagreement with the champions of the wilting process. After seven years field work with the forage harvester, however, it is my personal opinion that it is unnecessary, and certainly expensive, to ensile by a process that increases the labor, the total power input, and the weathering losses when it is usually possible to obtain the same results with the direct harvest method by increasing the length of cut, or, in cases of extremely high moisture or protein, by the addition of corn-cob meal or other dry carbohydrate. There has been no experimental work as yet to determine how far increasing the length of cut can go toward eliminating the need for a preservative. And since there are such large variations in kinds of crop and in the same kind of crop, the ensiling of grasses and legumes without preservatives cannot yet be unconditionally recommended. Excellent silage has been made, however, from an 80 per cent moisture, very immature alfalfa-wheat mixture and from an 83 per cent moisture alfalfa-brome mixture merely by increasing the length of cut.

Before considering the fourth requirement — economic practicability — it is necessary to see how the forage harvester fits into the other systems of harvesting forage, and how it is used on other jobs on the farm not directly connected with the hay crop. Nutritional experts report that no matter what the advantages of grass silage, it is still necessary to have some dry hay in the ration.

It has been suggested by H. E. Babcock that this need possibly can be eliminated, or at least greatly reduced, by a revised feeding program in which silage is kept before the cows in feeding pens at all times so that they can eat as they desire. He reasons that, if a cow can live entirely on 80 per cent moisture pasture grass in the spring and make her best showing in milk production, she should be able to get along on 75 per cent moisture silage that contains almost exactly the same proportion and amount of food elements as the pasture grass.

Assuming, however, that some dry hay must be used in the winter ration, with the forage harvester and its simple pickup attachment, the second crop can also be harvested as either field-cured chopped hay or barn-cured chopped hay. Use of the forage harvester in these two systems shows little improvement over conventional dry hay harvesting methods as far as the first and second requirements are concerned, but there is a marked improvement in the third requirement, reduced labor. In harvesting field-dried hay, the forage harvester runs a very close second to the new one-man baler in man-hours per ton of dry matter, and with the use of automatic unloading wagons does it easier. When it comes to barn-cured hay, the forage harvester so greatly reduces labor that it becomes the only really practical method of putting the hay on the drier.

Normally the direct-pasturing system of utilizing the forage crop is considered to be out of the realm of machinery, but with the forage harvester some benefits can even be obtained here. If in the spring, when the pasture crops begin to get ahead of the cattle, the pastures are clipped and the material ensiled, not only will an appreciable amount of good reserve feed in the form of silage be obtained, but the con-

dition of the pasture will be so improved that good grazing can continue for longer than the normal time.

Another method of handling the direct-feeding system, called "soiling", is relatively new and little used. But with the forage harvester it offers considerable promise. In this method the livestock is kept in the feed lot and the forage cut from the pasture, a load or two at a time, and fed as needed in feed tables or bunkers. A considerable reduction in pasturing losses is obtained by this method. Several farmers who have used the system report that from 50 to 100 per cent more cattle can be fed from the same acreage in this manner with only slightly more labor than was needed to care for the animals in the pasture.

Aside from meeting the first three requirements for all three systems of utilizing forage, the forage harvester performs other duties on the average livestock farm. Only the two most important of these will be discussed here. First, the same forage harvester equipment used for dry hay will greatly simplify the handling and storage of straw. Chopped straw makes much better bedding and takes less space than long straw, and can be handled through the forage harvester with a considerable saving of labor.

Second, with a simple row-crop attachment the forage harvester will do as much for the corn silage crop as it does for the hay crop. Here again the farmer and his son, or, in an emergency, the farmer himself, can harvest all the corn silage from the average size dairy farm with no outside help or heavy manual work. This completes deliverance of the farmer from peak labor worries and makes him independent and self-sufficient.

ECONOMIC PRACTICABILITY OF THE FORAGE HARVESTER

When considering the economic practicability of the forage harvester, and its necessary companion units, the blower and automatic unloading attachments for wagons, the work it performs all the way from the first silage crop through pasture clipping, soiling, dry hay and straw to corn silage must be considered. In all of these operations the over-all operating costs per ton of digestible dry matter from the field to the cow is lower when using the forage harvester than when conventional methods are used. This is accomplished chiefly through reduction of labor and simplification of operations. To this credit side of the ledger can be added the 10 to 30 per cent increase in total amount of digestible nutrients obtained from a given acreage that would be lost by other methods. Whatever gains are obtained in animal health and increased sales value of higher vitamin A livestock products can also be credited. The saving in commercial concentrate that did not have to be bought because of the high protein content of the silage is another credit. There are many more.

Against this side must be balanced the cost of the machinery necessary in the forage harvester system. As long as it is necessary to make dry hay, the farmer will need wagons, mower and rake, or wagons, mower and windrowing attachment, or wagons and swather. In the forage harvester plan we will need, in addition to the above, the forage harvester, pickup attachment, row-crop attachment, blower, and automatic unloading attachments for his wagons. In most cases the present power source in his tractor or tractors will be sufficient.

Use of the forage harvester plan will definitely eliminate the silage cutter, corn binder, hay loader, and hay forks from his present equipment. These displaced units will more than balance the cost of the blower, row-crop and pickup attachments, and unloading attachments for two wagons. Thus only the forage harvester itself must be added to his present investment to gain the benefits already pointed out. Under present conditions no one can forecast what farm machinery will cost in dollars and cents. A fair idea can be gained, however, by comparison. The forage harvester equipped for grass should compare very favorably in cost with a one-man baler or a six-foot grain harvester.

When this figure, whatever it will be, is depreciated over ten years, the additional machinery cost necessary to gain the credits pointed out becomes very reasonable. On many farms the saving in commercial concentrates alone will cover it. In no other major piece of farm equipment, except the tractor, will an equal investment solve the mechanization of as many jobs, or bring as large a return in cash, conservation of food, and reduced labor.

CONCLUSION

It has been shown that the forage harvester method of handling forage will increase production and lower costs of the basic food elements of the forage crop more than any other system or combinations of systems now known. The main points may be summarized as follows:

1 A very large loss of food and vitamins occurs every year due to present methods of harvesting forage crops.

2 Harvesting these crops as silage is the only known practical farm method by which an appreciable reduction can be made in this loss.

3 It is desirable, however, to handle part of the crop as dry hay for most livestock programs.

4 Another part of the crop will continue to be utilized by direct feeding.

5 The forage harvester is the only machine that will make more efficient the harvesting of the crop in *all* these ways and at the same time efficiently mechanize straw storage and row-crop ensiling.

6 It is the only machine that makes it possible for the farmer to organize a flexible plan of harvest that fits into all the changing conditions he encounters to give him maximum production at lower cost and at the same time give him easier work and independence from outside labor supplies.

It is apparent that this plan of harvest is a radical departure from present farm practices; that the conversion from a basically dry hay system to a basically silage system cannot be done overnight; that the rosy picture painted of economic practicability is not nearly as simple as it sounds. But this is where agricultural engineers fit into the picture. There is no other group that is better fitted to carry on the educational program needed, or to solve the remaining problems of practicability and adaptability that must be solved to put this plan into wide usage; this plan that will gain the utmost in increased standard of living through the mechanization of forage handling.

If it is agreed that the forage harvester can do as much for the American farmers' forage crops as the small grain harvester did for his grain crops, then there is a challenge to everyone to search for and solve any and all of the problems standing in the way of effecting an economic and practical conversion to the forage harvester plan.

Opportunities through Agricultural Engineering

(Continued from page 496)

ever, to provide an understanding not only of the natural and physical sciences, but also of the basic social and economic concepts that will lead to a full *appreciation* of the influences of these upon agricultural engineering, and vice versa. Agricultural engineering studies should probably include population analysis, community organization, types of rural government organization, analysis of social and economic institutions, social psychological behavior of rural people, the standards of living, and agricultural economics, treated from an institutional point of view.

In order to put these studies in their proper context, a study of the historic development of industrial society would be of considerable value. Requiring the agricultural engineering student to take the *conventional* course in such subjects as rural sociology, economics, psychology, economic geography, and industrial history, would probably require too great a proportion of the student's time. The subject matter needs of the agricultural engineer become more apparent as the profession grows and assumes responsibilities. The best results would probably be secured by engineers, recognizing these needs, working out the content of the needed courses in consultation with specialists in the supporting fields.

Other countries of the world recognize the need of foreign technical assistance and are search- *(Continued on page 504)*

The Buck Rake

By C. B. Richey
MEMBER A.S.A.E.

THE large-capacity transport type of buck rake, as distinguished from the old push type, sprang up in the adjacent areas of Ohio, Indiana, and Michigan about ten years ago. Since that time it has spread to all the major hay-producing states, although it has been made only by farmers and local welders. Most of these rakes have been mounted on old automobiles and trucks although a good many have been put on tractors.

The most complete data regarding this method of hay handling compared with other methods of mechanization, including balers and field choppers, has been secured in New York[1]. The buck rake method of getting hay from the windrow to the mow required fewer man-hours per ton than any other method except the field chopper method and the cost per ton was easily the lowest. The field chopper had a labor requirement of 1.4 man-hours per ton compared with an average of about 1.5 man-hours per ton for the tractor buck rake, but the investment in hay-making equipment was $1,831 compared to $279. Most of the buck rakes in this study were locally made and had power lifts with a hay-carrying area of 10x10 ft. Time studies were made on a group of 31 farms and loads averaged 753 lb as actually weighed.

The following composite time study of a complete buck rake load cycle is based on the above time studies, some time studies made by C. J. Steinbrunner for the A.S.A.E. Committee on Hay Harvesting and Storage in 1945, and on some time studies made at the Ohio Agricultural Experiment Station in 1942[2], all of which are in close agreement:

Load — approximately 700 lb (double-loading usually required to secure this quantity)	4.5 min
Transport to barn — ¼ mile at 6 mph average	2.5 "
Unload	1.0 "
Travel to hay — ¼ mile at 6 mph average	2.5 "
	10.5 "

The times shown for transport and travel can easily be corrected for other lengths of haul, although a higher average speed is often maintained on a longer haul because a greater percentage of the distance is usually on a lane or road which is not as rough as the hay field.

This covers briefly the performance of the most efficient buck rakes which have been available up to the present time. They have performed surprisingly well, but as would be expected in the case of a cobbled-up machine mounted on a worn-out automobile or truck, they have been subject to irritating breakdowns which tend to temper the enthusiasm of the owners.

There would seem to be an attractive market for well-engineered, commercially built buck rakes which will perform as well as the homemade variety and some of the design considerations are as follows:

It is not too difficult to build a buck rake which will mount on almost any automobile or truck chassis by drilling a few holes in the top of the frame. A hydraulic power lift seems to be most practical for a commercial rake and a small pump, valve, and reservoir assembly can be mounted on the frame near the motor where the pump can be driven by a small V belt running on top of the regular fan belt. The lifting cylinder is mounted so as to pull back on the rake uprights, and the control valve is operated by a rod extending into the driver's compartment. Such an outfit, if properly designed, will outwear several old cars and can be changed from one to another without excessive trouble. The commercial possibilities of this type are probably limited until such a time as reasonably sound old cars and trucks are as plentiful as before the war. However, farmers who already own pickup trucks might find it practical to remove the box and mount a buck rake of this type during the haying season.

The average farmer would prefer a tractor-powered buck if its performance equaled that of the auto buck. There are some inherent complications in the design of a tractor buck rake, and in the attempt to surmount these difficulties, several different types have evolved. Some of these are listed with the important advantages and disadvantages of each.

1 Front-mounted carried by tractor
   (a) Advantages: Inexpensive; fast loading speed.
   (b) Disadvantages: Low capacity if tractor front wheels are not overloaded; poor visibility for transport if teeth are lifted high enough to cradle load and prevent hay from dragging in the dust.

2 Rear-mounted carried by tractor
   (a) Advantages: Inexpensive; good visibility which allows fast transport speed; does not overload tractor.
   (b) Disadvantages: With light tractors the capacity is limited to the load which will not lift tractor front wheels off the ground; loading in reverse gear is slow with most tractors.

3 Front-end, carried on wheels of its own which steer with the tractor
   (a) Advantages: Does not overload tractor; fast loading speed.

(Continued on page 504)

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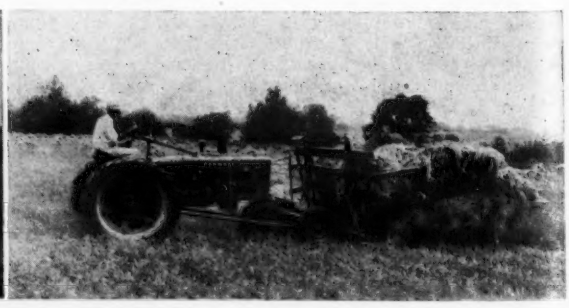
[1] Costs and Labor Used to Harvest Hay by Different Methods in New York, 1945, by Ellis W. Lamborn and L. B. Adkinson. A preliminary report of the departments of agricultural economics, agricultural engineering, and agronomy, Cornell University, in cooperation with the Bureau of Agricultural Economics, USDA.

[2] Buck Rake Performance in Hauling Hay and Grain Bundles, by C. B. Richey, Bimonthly Bulletin of the Ohio Agricultural Experiment Station, May-June, 1943.



Left: A large-capacity, transport-type of buck rake • *Right:* A front-end-type of buck rake carried on wheels of its own

The Twine Baler

By O. F. Scholl

THE importance of hay in the economic structure of the nation is well known. The production, harvesting, and storing of this important crop is a complicated and arduous task and only recently has it been receiving the attention it has needed for many years. While "packaged hay" produced by the automatic twine baler may not be the answer for all hay producers, it is one of the newer methods which has been very favorably received.

Three things are of major importance in the harvesting of hay: (1) a reduction in the amount of labor involved, (2) a reduction in cost, and (3) the production of high-quality hay.

Since the amount of labor involved has an effect on the cost of producing hay, there is a direct relation between the first two items. However, the kind of labor required is also important as there can be a great deal of difference in the amount of hard, physical labor in a man-hour of work.

In the production of high-quality hay, timeliness is more important than in the case of most other crops. The harvesting of the hay crop usually takes place in an extremely busy season because of competition from other crops, and, as a result, many producers of hay are especially interested in a method which will reduce the amount of time and labor involved. Before beginning this discussion of the automatic twine baler and its advantages, one thing should be emphasized: the other modern methods of producing hay which are now being studied and employed have a definite place, but each is restricted to certain farm operations and is hardly practical for all hay producers. The important question for each hay producer is: Will the method I employ put more meat on the animal or more milk in the pail, and if so, will the additional income received from the increase in milk or meat justify the additional expense of the method?

It is only nine years ago that the twine baler had its inception. The first of these automatic machines was conceived and built by Edwin B. Nolt of Lancaster County, near New Holland, Pennsylvania. However, it was not until 1940 that the first co. pletely automatic twine baler was put on the market for sale in any quantity. Credit for producing these first machines goes to the New Holland Machine Co., of New Holland, Pa. In 1944 the International Harvester Company produced the first of its version of this type of machine for sale.

In spite of the so-called "infancy" of this machine and the small quantity of these machines that have been produced, there is an unprecedented demand built up for this type of equipment. This demand has bordered on the phenomenal, and it is a good indication of the general acceptance of the machine, as well as the method of producing hay which it provides. It is true that the demand for all types of farm equipment is great at this time; however, the demand for this type of machine is far in excess of what could be considered normal even in these times.

Use of the automatic twine baler in the harvesting and storage of hay permits the individual farmer to utilize his regular farm power (tractor) and the barn equipment he already has (grapple forks, slings, corn elevators, etc.) without additional investment. The "packaged hay" produced in this manner is much easier to handle from the field to storage than long, loose field-cured hay. With the automatic twine baler and a tractor, it is possible for two men to harvest a complete crop of hay.

There are several methods which can be employed for handling the bales and each has considerable merit. The bales can be dropped from the baler to the ground and later picked up, either by hand or with a bale loader mounted on a truck or rack, for transporting to storage. A second method which can be employed is the use of a bale chute which takes the bales directly from the bale chamber and elevates them to a trailed wagon where they can be loaded for transporting to storage. A third method is the use of small sleds trailed behind the baler on which the bales can be arranged and discharged at intervals in the field. These small piles of bales can then be protected from the elements by the use of canvas or sisalkraft paper covers in case there is not sufficient time to take the bales immediately to the permanent storage place. In handling the bales from the rack or the truck, the regular grapple fork and hay sling installations in most barns can be utilized. Experience up to the present time shows that bales tied with regular baler twine, with an average tensile strength of 270 lb, can be dropped to the mow floor of most barns without damage. A second method for elevating the bales into the barn is the use of a conventional corn elevator for taking the bales from the truck or rack into the mow.

In this connection tests have been conducted at Iowa State College on the production of hay with the automatic twine baler. These tests reveal that the handling of hay from the windrow with the automatic twine baler and putting the bales into storage — with several different methods of collecting and storing the bales — averaged 1.61 man-hours* per ton of hay. This figure excludes the mowing and raking of hay since this factor is considered stable in nearly all current methods.

According to the unpublished thesis of G. L. Kline (Iowa State College, 1946) entitled "Harvesting Hay with the Auto-

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*Making Hay Easier, by E. L. Barger. State Dairy Directory of the Iowa State Dairy Assn.

Left: Rear view of the International Harvester automatic twine baler • *Right:* New Holland automatic twine baler in operation

matic Field Baler," the following *man-minutes* per ton are required in handling hay from the windrow to storage, using the automatic twine baler and various types of hay-handling equipment: two trailers and barn fork, 80.3; towed trailer and barn fork (no stacking in the barn), 61.9; towed trailer and grain elevator, 74.0; towed trailer and hand unloading, 78.1; bale loader and barn fork, 95.2; bale loader and barn fork (no stacking in the barn), 70.5; bale loader and grain elevator, 88.9; bale loader and hand unloading, 93.0, and hand loading and hand unloading, 104.9. The actual man-hours required for only the baling operation, which are included in these man-minute requirements, amount to 0.23 man-hours per ton. In one test run of 6,978 bales in good alfalfa hay, the average man-hour requirements for baling amounted to only 0.19 man-hours per ton.

Because of the speed at which hay can be harvested by this method, it is possible for the hay producer to take advantage of two or three days of good weather for putting up hay. The many radio stations scattered through the hay-producing areas give at least daily forecasts of weather, making it possible to take advantage of the good periods to put up the hay crop and reducing the hazard of losing all or part of it due to inclement weather.

When using the automatic twine baler, the hay can be raked into windrows of the right proportion as soon as the top of the swath is wilted and thus effect a saving in the leaves of the crop. After further curing in the windrow, to bring the moisture content of the hay down to 20 to 25 per cent, the hay is ready for baling. The pickup action on the baler is a smooth, easy process and much of the leaf loss incurred in some other hay-making methods is avoided. Since there is a direct relation between the amount of leaves saved and the digestible nutrients of finished hay, the quality of the hay produced by this method is very good. Preliminary experience in the barn drying of hay, baled with about 35 per cent moisture content, shows definite promise. While no conclusive evidence is available, preliminary tests have produced encouraging results. Since the twine-tied bales are less dense than the conventional type bale, they lend themselves well to this type of drying.

BALED HAY HAS ADVANTAGES FOR STORAGE

In the storage of hay, a packaged product as produced by the twine baler has definite advantages. It permits the storage of more hay in a given space than is possible in the storing of long loose hay, and it permits definite segregation of different types of hay and different cuttings of hay. The piling of bales in the barn is easier work than the tearing apart and the spreading of long loose hay in the mow. In this connection, preliminary tests reveal that bales dropped in the mow by the conventional grapple fork can be left in the disordered manner in which they fall and there will be good circulation throughout the hay for further drying in the barn. The same tests reveal that it is possible to store as much hay by this method as most barns are structurally able to stand. The amount of hay stored in this manner is equal to the amount of long, loose hay that could be stored in the same mow.

The feeding of twine-tied baled hay is an easier job than the feeding of any other type of hay. The baler builds each bale of separate layers and compresses them together into the bale. This unit construction provides easy separation of the layers and prevents loss of leaves when feeding. Furthermore, there is no danger to livestock if a small amount of twine is left in the hay as there is with wire that might be overlooked.

The ever-increasing use of hay in soil conservation and crop rotation makes it necessary for the individual farmer to put up his hay in a form which can be stored for longer periods or readily sold. "Packaged hay" is a premium product and will bring a premium price when it is sold. The only figures available on the amount of hay which is sold in this country are those of hay marketed through regular marketing channels. While this figure varies from year to year, the amount of hay sold by producers to other farmers and feeders in the immediate neighborhood is also a large factor, and the producer who bales his hay will find a much better market for his surplus crop.

The tenant farmer's problem in the production of hay is largely answered by the use of the automatic twine baler, as he can package his hay, and if forced to move, it can be either transported to a new location without loss of quality, or it can be sold at a premium price.

The tying mechanism of the twine baler is, in principle, similar to that used on grain binders and consequently one which is familiar to the average farmer. The twine used by the baler has an average tensile strength of about 270 lb and experience has shown that breakage in handling bales tied with this type of twine is no greater than that of wire-tied bales. The twine-tied bale — made of separate layers of hay — is less dense than the wire-tied bale and is lighter to handle, both when storing and when feeding. A decided preference has been expressed by stock feeders for the twine-tied bale due to the ease, and consequent saving in time, with which this type of hay can be fed. The wire baler produces a heavier bale and consequently a more suitable bale for hay that is to be transported long distances by truck. In addition, straw and other products processed for strawboard purposes should be tied with wire because of the requirements of these industries. These requirements for a wire-tied bale constitute only a small portion of the total requirements for baling of hay and straw.

HAYMAKING RESEARCH ACHIEVES RESULTS

During recent years much study and a large amount of research have been done on the subject of haymaking. Much has been accomplished by this study and research, and methods have been evolved which lend themselves very well to certain farm operations. Methods for the large operator who can afford to have a barn-drying installation and for the dairyman who has or can afford a silo for grass silage have been receiving a great deal of study. However, there is no factual evidence that the small hay producer can afford these methods. U. S. Department of Agriculture figures reveal that on the farms growing hay in 1940 there was an average acreage of 21.7 and an average production of 28.6 tons of hay. From these average figures it is reasonable to assume that a large proportion of the hay producers can be classed as small producers. With this group in mind, it is important that work be done to improve the quality of hay produced and to reduce the cost and amount of labor required.

In this connection, there are several suggestions for further study which could be of help to all hay producers:

1 It is a well established fact that a large portion of the nutritive value of legume hays is contained in the leaves. If a legume plant could be developed which would yield as well as present strains and have a greater resistance to the shattering of leaves, it would be advantageous for all hay producers regardless of the methods used in harvesting.

2 Present demand for the automatic twine baler indicates that a large portion of the hay will be put up in the form of "packaged hay". While considerable research has been done on farm structures, "packaged hay" will no doubt bring about further changes, which will benefit those who wish to put up their hay in this manner.

3 The development of smaller hay processing units with a lower original investment and low operating costs which would aid in the production of quality hay should have a definite appeal to the small producer.

Experimental Mole Ditcher

(Continued from page 494)

sure of the soil wall of the drain to air and water rather than to collapse due to structural weakness, or to clogging due to silt filling the drain. These results suggest the possibility of investigating a soil binder that would stabilize the soil wall of the drain and still leave it porous, or the introduction of a material that would form an impervious lining for the drain that could be perforated or cut by a tool following the shell to allow water to enter the drain.

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Automatic Wire Hay Balers

By F. D. Jones
MEMBER A.S.A.E.

THE primary reason for baling hay is to put it into a desirable form for handling, for selling or storing, or for both. In order to get the hay to market, it must be transported and the bales must retain their shape after handling and shipping; so they must be well-formed and durably bound. The market demand for a baler depends on how well it does this job. Of course, the capacity, weight, simplicity, and cost of the machine enter into the picture, but the machine must perform the above function in order to justify its manufacture.

Until recently hay buyers have been accustomed to wire-tied bales. It would be shortsighted to assume that wire-tied bales will always be the most commonly seen on the market, as other materials more suitable might develop, or some existing material might be adapted to this purpose and become popular at any time. The reason wire is popular now is that it is economical, easy to obtain, strong, uniform in strength and form, is durable, is not attacked by insects or rodents, and can be put in a compact form for transporting and storage.

It was with this in mind that the automatic wire-tying balers have been and are being developed.

Anyone who has worked on the problem of developing an automatic hay baler for wire, I am sure, is impressed by the large number of patents issued in comparison with the number of machines manufactured. These patents started to issue about 1892. At the present time there are only two machines on the market which are fully automatic. No doubt, development work is progressing on others.

In this paper I will attempt to state and explain some of the requirements which are desirable in an automatic wire baler.

In order to be in demand in volume, an automatic wire-tying baler should operate satisfactorily with the popular types of tractors now being used and sold. It would be unreasonable to expect a farmer to buy a larger or special tractor just to operate his baler.

A successful machine should be versatile enough to handle all of the materials ordinarily baled in the country today. These include all kinds of hay from short alfalfa to long timothy and Johnson grass and from dry, fine oat straw to long-stemmed, coarse soybean hay which has been stacked. It should operate satisfactorily both as a field or stationary machine.

Another requirement is that the machine must have a capacity in tons per hour equal to the present hand-wired windrow pickup presses. A large number of farms have sizeable acreages of hay, and it must be handled promptly when it is ready to harvest. Also, in many sections of the country, the time per day that hay can be baled is limited to a comparatively few hours; and, if the machine has plenty of capacity, more of the hay can be harvested in its optimum condition and when weather or other conditions are favorable.

Another is that the machine must be capable of working in more severe conditions than the hand-operated machines. A hay baler owner finds it difficult to get help to work on a windrow pickup baler when there is an extreme amount of dirt in the hay being baled, or the ground conditions are such that a large amount of dust is raised in going over it. A large amount of hay is baled in hot weather, and dust and heat together make very undesirable working conditions. We have seen automatic machines working in conditions where owners told us they would not be able to get men to work on the hand-tied machines. If it were not for the automatic baler, they would have had to put the hay up in some other manner.

The baling mechanism must be durable. When a machine requiring three or four men is operated, there are more stops, and it is not run as continuously as when one man operates it. To aggravate this situation, the one man who does operate the automatic machine is generally the owner and naturally runs it more continuously than several hired men.

The wire splices made by the machine must be strong, approaching as nearly as possible the ultimate strength of the wire; that is, if the machine is to use the usual type of annealed wire in the ordinary sizes used in baling hay. A 75-lb bale of hay 38 in long stresses the wire considerably, especially when it is handled by the wires. When bales are not baled solid enough and they are piled up for storage or on trucks for transporting, the ones on the bottom crush and cause trouble. As stated above, one of the reasons for baling hay is to put it into a form in which it can be handled, and some baled hay is handled a large number of times before it is fed. Anyone who has watched truckers handle baled hay will appreciate the fact that the bales must be well tied.

The splice must be of a type that can be made quickly. These machines are expected to make at least two bales a minute, and a baler running at this rate of speed must twist the wire in a maximum of about two seconds, if it uses the conventional method of splicing the wire at the same time it is inserted between the bales.

The splicing mechanism must be simple and rugged. These machines are like all other farm implements: they are allowed to set out in the weather and expected to operate after being out over a period of time without much attention. If something does go wrong, it must be simple enough that the average farm hand can repair it and get it into operation in a minimum length of time. A large number of automatic wire splicing mechanisms for hay balers have been devised and built. Most of them do not fulfill the above two requirements. They are too slow and too complicated.

The machine should be capable of using wire of a grade which the wire concerns can supply in volume at an economical price. The mechanism should take ordinary variations in

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Two views of the John Deere automatic wire hay baler

wire size and hardness in its stride. It should accommodate wire which has been put up into a form in which it can be easily stored and transported and can be protected from deterioration while in storage. The place on the machine provided for the wire should be located so that the supply can be replenished conveniently and quickly, and where the supply can be watched by the operator. The wire mechanism on the baler should be constructed so that its operation will not be affected by oil, lacquer, or other materials used to protect the wire from corrosion.

It is advantageous to have the important operating parts of the machine visible to the operator from his position on the tractor, so that if something goes wrong, too many unwired bales will not be discharged from the machine. It is also a good thing if the operator can see the bales as they are discharged so that he may make the necessary adjustments promptly to maintain their good appearance.

Bale loaders are growing more popular and most of these pick the bales up lengthwise. For this reason, a field baler should discharge its bales with the long axis parallel to the line of travel.

The transmissions and compression chambers of hay balers are often subjected to large stresses, due mainly to variation in the moisture content of the hay and careless operation. It is therefore important that the machine be equipped with sufficient safety devices to protect the parts which would be expensive to replace, if damaged, due to extreme overloading of these parts.

We have all heard arguments pro and con about the desirability of a motor-driven or power-take-off-driven automatic hay baler. The problem is different from that of a combine thresher to which it is often compared, as speed variation has little effect on quality of the work being done. I believe that if plenty of power is available for the baler through the power take-off, and the tractor has plenty of range of variation of ground speed, that power take-off operation is satisfactory, and the cost of a motor is saved. However, if the power available is marginal and/or the travel of the tractor over the ground cannot be slowed down enough to allow the baler to handle the occasional heavy windrows which are always encountered, a motor is desirable. A continuous running power shaft with a separate clutch would enable a power take-off machine to operate more satisfactorily in these conditions, as it would make it easier to shift gears on the tractor. Individual owners baling their own hay will rake it to best suit the operation of the baler, so power take-off drives are generally satisfactory for them. Custom operators, no doubt, will find that a motor is a profitable investment.

Light weight is very desirable. These machines are often operated on soft ground, and farmers object to having their fields marked up with the wheels of implements being pulled through them.

The general characteristics of a good machine apply to an automatic wire baler the same as to any other implement—that is, it should have a good, clean appearance and be compact. Operators often have to transport these machines on the highways and through barnyards, into close corners of fields, through gates, and in other close places. This makes a compact machine desirable. It is also an advantage when the machine is shipped and stored.

The Buck Rake

(Continued from page 500)

(b) Disadvantages: Poor visibility for transport with large loads and teeth lifted high. (As an example, I recently heard of a farmer with this type of buck who rolled a new side-delivery rake into a pile of junk before he realized it was in front of him. Even when standing up on a high tractor, the driver cannot see the ground within about 200 ft of the outfit and this is serious from the safety standpoint).

4 Front-end, carried on wheels of its own, attached by a V frame pivoting at the front of the tractor

(a) Advantages: Does not overload tractor; quickly attached.

(b) Disadvantages: Very poor visibility with large loads and teeth lifted; method of steering limits loading and transport speed. (This type of rake has been gaining ground in the West where it is used for bringing hay to the stacker.)

5 Rear-end, carried on wheels of its own and attached by a V frame pivoting at the tractor drawbar

(a) Advantages: Does not overload tractor; quickly attached; excellent visibility and resulting fast transport speed; good maneuverability in close quarters; V frame can have box mounted and be used as a trailer when not used with buck rake.

(b) Disadvantages: Loading in reverse gear is slow with most tractors; a certain degree of skill must be acquired for loading, although, if the ratio of V-frame length to tractor wheelbase is not too small, the average operator will easily acquire this skill in half a day's operation.

Of the types listed, I favor the last for tractors which have a reverse speed of 3 mph or better. However, the fact remains that the best position for loading is in front of the tractor and for transport behind the tractor.

A power lift is a prime requirement as the teeth should be lifted to a height of at least 6 ft at the ends to lift hay clear of the ground, to cradle grain bundles so they do not fall off, and to reduce the overhang of the load.

In view of the demonstrated performance possibilities of the buck rake in speeding up haying and reducing hand labor at a minimum cost it would seem to deserve more attention from manufacturers than it has apparently received. A satisfactory transport type of buck rake is considerably more expensive than the old type adapted only for pushing hay a short distance to the stack, but if it will move hay to the barn twice as fast, it is worth three times as much to the farmer.

Opportunities through Agricultural Engineering

(Continued from page 499)

ing for United States technology and skill. At present the prestige in most foreign countries of the United States engineer is higher than he deserves and is probably higher than the capabilities of the mortal engineer will warrant for generations to come. Present opportunities for human advancement through the application of agricultural engineering set the *goal of competence* toward which the agricultural engineer should strive. He must be competent to recognize the need for the application of the findings of *all* the sciences to the task in hand. The engineer must be peculiarly adept in securing the collaboration of specialists and in utilizing science to determine the needs, aspirations, and capabilities of people and of their institutions, and in the application of science to man and to materials to meet these needs. To the extent that the engineer deals skillfully with the application of science to man and materials for the benefit of man, he will promote the economic and security interests of the United States and advance the economic, social, and political stability of the world.

Early Engineering Training

Here are rules from an American school as published in 1874: "We prohibit play in the strongest terms . . . students shall rise at five o'clock in the morning, summer and winter."

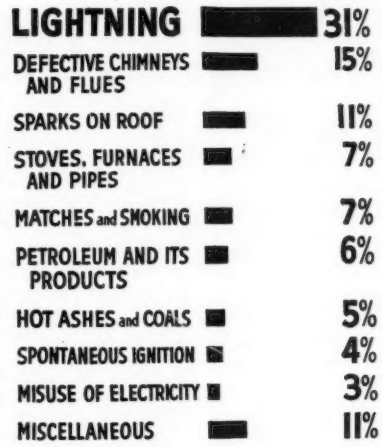
The following is from an announcement from Rensselaer Polytechnic Institute early after its inception: "Students of the engineer corps are instructed as follows: Eight weeks in learning the use of instruments (as compass, chain, scale, protractor, level, etc.) with their applications to surveying, leveling, calculating excavations; eight weeks on mechanical powers, circles, conic sections, construction of bridges, arches, railroads, canals, running circles for railways; four weeks in calculating the quantity of water per second supplied by streams as feeders for canals or turning machinery; four weeks to study the effect of steam and wind as applied to machinery."—From "The Journal of Engineering Education," September, 1947.

Safe Lightning Protection

By R. D. Bienemann
MEMBER A.S.A.E.

ALTHOUGH many thousands of buildings are protected against lightning, it still is the prime cause of farm fires. Lightning accounts for 31 per cent of the country's annual farm fire loss, double that of the second greatest cause, defective chimneys and flues. (See accompanying list of causes of farm fires as compiled by the National Board of Fire Underwriters.)

In Iowa, during a two-year period, 503 unprotected buildings were damaged to the extent of $1,060,668, an average of $2,000 per building. In the same period twenty-eight so-called "protected" buildings were damaged. The loss ratio on "protected" buildings in this particular case is very small, approximately 5 per cent of the unprotected buildings. Unfortunately, for our present purpose, no attempt was made to check condition and original adequacy of the lightning-protection installations of these twenty-eight "protected" buildings. Obviously, however, these installations could not have been classed as "safe lightning protection".



Causes of farm fires as compiled by the National Board of Fire Underwriters

What constitutes safe lightning protection? In order to determine what procedure to follow in the installation of lightning protection, we must first have a knowledge of the phenomenon "lightning", and its action under various circumstances.

When storm clouds gather they store up on themselves great quantities of electricity. These static charges may be either positive or negative with respect to adjacent objects or masses; hence the reason for many discharges from cloud to cloud. In lightning, as in all of nature, opposites attract. These atmospheric discharges result in the major concussion of a storm, but cause no actual damage since they do not reach the earth.

While such a storm is approaching, much unseen activity takes place on the surface and inside of the earth. Many millions of negative charges are attracted and drawn by the positive of the atmosphere to points at, near, or in contact with the ground surface. The pressure becomes intense as they flow to the highest elevation possible, preferably following a low-resistance metal path, but otherwise utilizing a chimney or building of relatively non-conducting material. When the pressure or potential becomes sufficiently intense, a portion of the negative charge is pushed off into the atmosphere and bridges the space between its point of origin and the positive charge in air or cloud, with the release of millions of volts and thousands of amperes of pent-up energy.

All of this is completed in a fraction of a second. We have seen the flash of lightning, and heard the crash of thunder, and if our barn or house is still secure we are fortunate.

Scientific development during the years has not been able to prevent the phenomenon from occurring in all cases, but has given us the possibility of preventing any damage to our buildings through the installation of safe lightning protection. We have learned through scientific research and experience that a properly installed lightning protection system provides practically 100 per cent protection from the menace from the sky.

Actually lightning protection in the modern manner does prevent what we call a bolt or stroke in *most* cases. As we learned in high school physics, the density of charge is most intense at the more remote parts of a charged body, and especially at the end of a pointed extension. From such densely charged points the static electricity leaks off rather rapidly into the surrounding air. This is the main reason why air terminals are sharply pointed, and to secure a sufficient capacity for dissipation is one reason for the number of points employed.

In rare instances the charging rate may so exceed the dissipation rate that the potential rises high enough to break down the dielectric resistance of the air, and a stroke of lightning occurs. In a well-designed system this is unlikely unless there is a break in the continuity or conductivity of conductors or connectors, or an abnormally high ground resistance. Nevertheless an adequate system always is designed with conductors of such low resistance and such high thermal inertia that they will not melt under a disruptive discharge.

During the dissipation phase of static discharge, the resistance of conductors is of no consequence, but low resistance or certainty of contact with the earth and among the parts of the system is important. If dissipation becomes inadequate and a stroke occurs, everything changes. We have an alternating current or oscillating discharge at fantastically high frequency. Not only must resistance be low enough to handle thousands of amperes, but the inductance must be held close to zero.

Both theory and experience teach us that there must be not a single path, but parallel paths for the high-frequency discharge, and that these paths should be arranged according to a pattern. Hence we usually have at least two each of air terminals, ground electrodes, and connecting cables.

The shape or design of a structure will govern the number of ground electrodes and paths necessary. Single-ridge structures, with no ells or tees, up to 80 ft in length require two ground terminals; from 80 to 140 ft, three; 140 to 200 ft, four; and one

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This fine group of buildings on the Stenning Farm near Lake Geneva, Wis., is equipped for safe lightning protection

additional ground terminal for each 60 ft of additional ridge. If a building only 40 ft in length has an ell or tee of equal height or lower, such a structure requires three grounds. Any dormer wholly between the eaves and ridge requires the coursing of the conductor cables over it, and frequently also an additional ground electrode.

The basic portion of a system of "safe lightning protection" consists of the familiar ground electrodes sunk to a depth of at least 10 ft where soil conditions permit. Auxiliary grounds are frequently required where rock formation or dry sand is encountered. In such cases ground electrodes are sunk to the maximum depth possible, and additional electrodes added each 6 ft diagonally out from the building, for distances of 12 ft or more. Where ledge rock is encountered, it is frequently necessary to bury cable in a trench for a considerable distance to supply adequate grounding, or a belt cable installed around the perimeter of the building, with ground electrodes driven wherever possible and not in excess of 50 ft apart.

To the driven ground electrodes are attached the cables. One is coursed up the post of the structure to the rafters, up the face rafter to the ridge, and along the ridge to the diagonally opposite corner in like manner, and down to the second ground electrode, thus completing a ground-to-ground circuit. To the ridge cable are attached the air terminals. These are not the grotesque, highly-trimmed, 5-ft and higher ones of bygone days, but neat, almost invisible, substantial units, each consisting of some form of saddle and a 10 or 12-in copper bar point. When this portion of a system is installed, which is practically identical with a completed system of years ago, the most important portion of the system still remains to be installed, the interconnections.

WHY INTERCONNECT ALL METAL MASSES?

Practically all buildings today are equipped with running water, necessitating the interconnection of the water pipe at its point of entry, and in addition the vent stack or stacks on the roof, all metal eaves, down conductor pipes, door tracks outside and inside, hay carrier tracks, ventilators, litter carrier tracks, electrical, radio, and telephone grounds, etc., and any such masses of metals as may be bodies of either inductance or conductance.

Why interconnect all of these metal masses? Because each and everyone of them becomes charged, and unless these bodies are brought to the same potential as the lightning protection system, a side flash can and does occur, frequently damaging and perhaps destroying the so-called "protected" building, and leaving the impression that lightning protection may fail to protect.

The most important of these interconnections is the water system, for the reason that it passes through the earth, often for a considerable distance, gathering negative charges and carrying them into the building. If this water pipe is not connected to the lightning protection system, such charges may and do become sufficiently dense to cause the positive charge to follow the lightning-protection cable to a point where the density is great enough to arc through the walls of the structure, causing fire or shattering.

If the resistance at this point is such as to create high heat, a fire will result. Otherwise only shattering may occur, and perhaps injury or death to persons or animals in contact with the water pipes. Only in recent years has running water been generally installed in rural areas; hence the reason why the majority of lightning protection systems previously installed are incomplete today.

Metal hay carrier tracks are the next most important item to be interconnected with the lightning protective system. There are still many wooden hay carrier tracks, but they are gradually being replaced by metal, and few farmers realize the need to interconnect this dangerous item to the lightning protection system.

Modern ventilating systems should be interconnected both at the intake and exhaust. Other important interconnections include door tracks, both inside and outside, litter carrier tracks, eave troughs, down conductor pipes, as well as milking machine pipes. A side flash may occur to a grounded conductor from any one of these, and while they may not always be in close proximity to the lightning protective system itself, they may be very close to a water pipe, ventilator intake, or any other conductor already interconnected to the lightning protective system. Hence a connection must be made between such items and grounded conductors to provide absolute safety.

With the improvements in our construction methods for farm buildings, and work simplification in and around them, the simple lightning rod of grandfather's day becomes an engineering problem, one that demands installation by a qualified technician. The lightning protection field does present a limited number of opportunities for careers for agricultural engineers.

With these complexities in mind, you may ask, "How can I be sure the lightning protection I plan to install or to recommend will give 100 per cent protection"?

There is now only one positive assurance. That is to insist, before investing one penny, that the installer supply an Underwriters' Laboratories master label on the completed installation. The Underwriters' Laboratories have prepared a "Code for the Protection Against Lightning" that is in conformity with the National Fire Protection Association, the U. S. Bureau of Standards, and the National Electrical Code. This lightning protection code sets the standards for master label installations.

On completion of an installation under their master label service the installer fills out a report, which must be signed by the property owner attesting the depth of the ground electrodes. Also signed by the installer, it is forwarded to the manufacturer of the equipment for his signature, and then it goes to the Underwriters' Laboratories for issuance of their master label. This master label is then mailed to the manufacturer and is forwarded by him direct to the property owner.

Further than this, the Underwriters' Laboratories maintain a crew of inspectors in the field and inspect at random not less than 30 per cent of each installer's work each year. Should any system show deficiency, a 100 per cent inspection of that installer's work is made and he is required to return to the installations and without charge make any corrections they may require. Should he refuse he is suspended, and the manufacturer involved is held responsible for the correction of the work, or he, too, is subject to suspension.

MORE THAN 103,000 U. L. MASTER LABELS ISSUED

The records of the Underwriters' Laboratories, during the twenty-four years they have accepted lightning protection, show a remarkable history. More than 103,000 master labels have been issued, and only a fraction of 1 per cent of all of these labeled installations have shown even the slightest damage. On investigation of these damages, it has frequently been found that they were caused by the addition of equipment that should have been interconnected, or the erection of additions, chimneys, etc., and the failure of the property owners to notify the installer of the lightning protection equipment of such changes or additions.

The most satisfactory material for lightning protection systems, for physical and chemical properties, for dependability and permanence, as well as conductivity, is pure copper cable. With it should be used driven ground electrodes, adequately strong copper bronze or stamped copper clamps and connections, preferably of the screw type, or pressure clamps capable of holding the resistance down to a minimum.

The resistance of a driven ground electrode should at no time exceed 25 ohms, and on the completed system be even less. In good moist earth conditions the resistance for a ground electrode is frequently less than one ohm, and in such instances readings on a completed system often show 2.5 ohms or less.

I would emphasize two things: First, know your installer. Second, insist on an Underwriters' Laboratories master label on the completed installation before investing any money. Thus you may have peace of mind in knowing that loved ones, livestock, and buildings will be safe from the menace of the sky. The fully protected structure is one which never reveals its need for protection.

Applying Stubble-Mulch Tillage in Virginia

By R. C. Hines, Jr., J. H. Lillard, Jr., and T. W. Edminster

MEMBER A.S.A.E. MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

THE science of conservation farming has progressed very rapidly in recent years. Fairly accurate appraisals of soil and water losses to be expected under almost any conditions can be made. Much research effort is now being placed on improved farming methods, particularly on tillage tools and practices.

Even the best-known conservation practices do not offer complete protection against erosion. Contour strip cropping, for example, is a highly successful conservation practice but experimental measurements show that soil movement does occur in the open cultivated strips; the extent of this depends largely upon land slope and intensity of cover. In the ridges and valleys area, practically all land is rolling to steep, thereby requiring the cultivation of large areas having greater slope than can be protected when using present conservation practices. This is necessary to attain a balanced farm operation. The solution of this problem lies in the development of additional conservation practices to protect open-cultivated crops on these sloping fields from damaging soil and water losses.

The energy of falling raindrops is recognized. The impact of the raindrops tends to disperse soil structure. This reduces the infiltration rate of the soil and promotes runoff. Mulch cover to intercept these raindrops and dissipate their energy is therefore necessary. In order to hold the movement of surface water to a minimum, this additional protection must be given to the soil. The application of such materials as straw and manure furnishes such protection. So do the residues of previous vegetation. These vegetal residues are the most practical in that they are readily available to all farms. Their beneficial action is threefold: (1) To break the fall of the raindrop and expend its energy, (2) to impede the surface flow through innumerable obstacles, and (3) to promote infiltration through maintenance of an open soil structure.

The over-all purpose of these investigations is to evaluate the potentialities of the stubble mulch practice in the conservation of soil and water under Virginia conditions. Initial effort was devoted to local experimentation with easily procurable conventional mulch culture tools which have been successful in varying degrees in other sections of the country. These studies led to trials of other tools and combinations of tools, both conventional and new, in an effort to devise practical and efficient methods of applying the principle of mulch tillage to Virginia farming methods.

Experimental Methods. In the first year of experimentation, three tools were used: the moldboardless plow or share, the sweep, and the disk were checked against the conventional turn plow-disk method of seedbed preparation. This procedure was followed because it represented a pattern that had been found fairly successful in other sections and because these tools were easily procurable. The share and the sweep were found to be inadequate; weed growth and the regrowth of perennial vegetation were excessive, creating moisture competition, and a plant nutrient deficiency developed because of the slow organic matter decomposition during the early growing season. This latter condition exists in the ridges and valleys area where the temperature of the upper soil profile is not high enough to promote optimum bacterial action until after the crop growth is well along. The yield of the sweep and share plots was from 50 to 75 per cent below that from the conventional plow-disk plots. The same difficulties to an even more marked degree were encountered with the disk plots as were found in the share and sweep plots. The yield was cut by approximately 80 to 90 per cent.

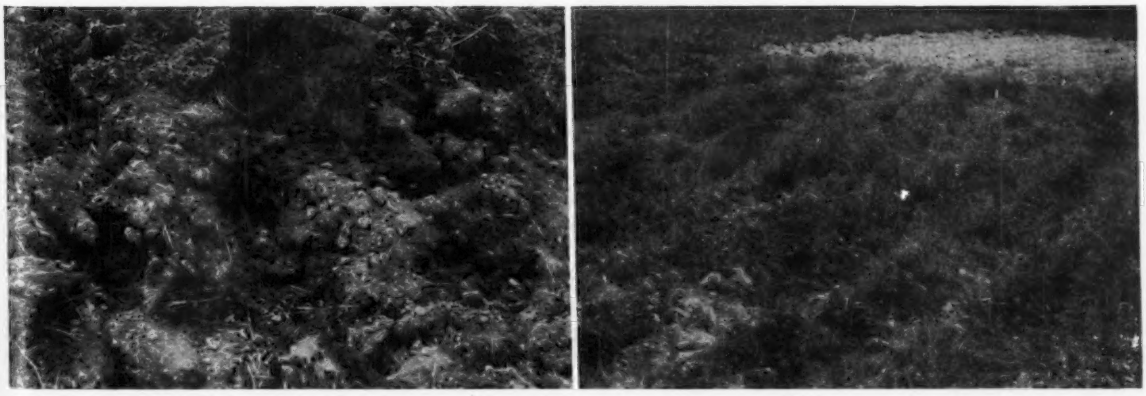
During the second year, the same tools singly and in combination with other tools were tried in an expanded plot program. Some of these combinations were the ripper and chisel, ripper and sweep, ripper with disk, ripper with the disking done immediately prior to seeding, and ripper and disk with tredders.

It was found that the more thorough the subsurface cultivation the better the seedbed preparation and the higher the yield. The rippers together with the disk and tredder gave a better seedbed preparation than any other method. It was observed in both the first and second year that it was necessary for a certain amount of organic matter to be incorporated when the seedbed was prepared in order to have the plant nutrients released in time to support vigorous early plant growth.

In a separate study the time of seedbed preparation was varied from a date early in January to one immediately preceding the planting of the crops in early May. It was found from these plots that tillage done early in the season gave a

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Biloxi, Miss., January, 1947. It is a contribution of the soil and water conservation project of the agricultural engineering department, Virginia Agricultural Experiment Station, in cooperation with the Soil Conservation Service, U. S. Department of Agriculture, and the Tennessee Valley Authority.

R. C. HINES is assistant agricultural engineer, and, J. H. LILLARD, JR., is project leader in soil and water conservation, Virginia Agricultural Experiment Station. T. W. EDMINSTER is project supervisor, Soil Conservation Service (Research), U. S. Department of Agriculture.



(Left) A close-up showing surface condition following tillage with a ripping type of implement. Note good water intake capacity but poor seedbed conditions • *(Right)* The area in the foreground shows surface conditions shortly after tillage with a sweep-type implement. Comparison may be made with the conventional plow-disk plot in background. These conditions are indicative of the vegetation regrowth and seedbed problems

greater weed and regrowth problem; hence, the plants had severe competition for water and plant food. The weed and regrowth problem on the plots that were prepared later was less severe; but less time was provided for decomposition of organic matter, thereby resulting in an even greater reduction in plant-food release in the early growing season. Because of these conflicting effects, the proper time for stubble mulch seedbed preparation is a matter for continued experimentation.

The most promising of the new tillage methods for mulch culture reduced the crop yield by approximately 20 per cent below that of the check areas. The plots receiving the most thorough treatment (i.e., rippers and combination of rippers and disk and tredders) reflected higher yields than other stubble-mulch methods.

By 1946 the general interest in mulch culture in Virginia had reached the point where it was again necessary to expand the experimental layout. Additional land was secured and a randomized plot system including 16 different replicated treatments was installed. The treatments showing the most promise during the previous two years of study were repeated together with the following new ones:

1 Turn plow to a depth of 3 in in March plus ripper before seeding
2 Ripper twice in early April
3 Ripper once in early April and once immediately before seeding
4 Disk plow in March plus disking before seeding.

In addition, a selected number of the plots which had the various tillage treatments also received side-dressing applications of supplemental nitrogen during the growing season. While the 1946 results have not been summarized as yet, the observations indicate the same trend which were evident during the preceding two years. The side-dressings of nitrogen tended to increase the yields slightly, and showed some improvement in the crop vigor, but this relative improvement did not vary appreciably among the different tillage practices. The same trend of increased crop yield with increased thoroughness of subsurface cultivation prevailed in the 1946 results as it had in the previous two years of study.

Discussion of Results. The results of the three years of experimentation in Virginia have clearly delineated a series of problems which must be emphasized in future research before the potentialities of stubble-mulch tillage as an essential practice can be adapted to a soil and water conservation program in the limestone valleys and the upland region. Chief among these problems are (1) the effect of these various tillage practices on the seasonal availability of plant nutrients, (2) the regrowth of the perennial grasses and legumes following the initial tillage operations, (3) increased weed growth, and (4) stand reduction.

In the generally high altitudes of the ridges and valleys area, the spring season is usually cool and wet and is not conducive to fast disintegration of organic materials. This situation coupled with the problem of eliminating plant regrowth makes it impractical to perform tillage operations too long before the seeding date. On the other hand, the later the date of tillage operation, the less time is available for bacterial release of plant food elements needed to insure a vigorous early growth of the crop. A further problem arising in this connection is the amount of vegetal cover which should be incorporated in the soil profile in the initial tillage operation to insure optimum plant-food release, and at the same time leave sufficient cover to provide effective erosion control. Studies thus far indicate that even when the optimum conditions prevail it may still be necessary to add supplemental fertilizer, particularly nitrogen, to insure the initial plant food release impetus desired.

The general agriculture of the mountainous region is developed around a three or four-year rotation involving one year of corn, one year of small grain, and one or two years of meadow. The climate and soils are ideally suited to vigorous growth of grasses and legumes; consequently, practically every field that is plowed for an open cultivated crop is heavily vegetated with various types of perennial grasses and legumes. The soil at plowing time contains an immense number of live roots making it rather difficult to till with the conventional stubble-mulch equipment. It has been impossible to achieve sufficient separation of this type of vegetation from the soil mass to effect a satisfactory "kill" in the preparation of the seedbed. Live roots and crowns in the soil are not killed by these tillage operations, but only await the occurrence of proper climatic conditions to begin a vigorous regrowth which offers too much competition to the cultivated crop that has to develop from seed. This condition emphasizes the necessity for further research aimed at the development of new equipment better adapted to these grass-land conditions.

The problem of weed control is one which is likely to be troublesome under almost any type of subsurface tillage. Perhaps it indicates the necessity for a wider adaptability of flame cultivation and chemical weed control and/or the modification of existing cultivation equipment.

The difficulty of obtaining a satisfactory seedbed by subsurface tillage and surface compaction, due to the tough and dense sods encountered, makes it exceedingly difficult to obtain a satisfactory crop stand. The crop stand obtained by the various mulch tillage methods has been in direct proportion to the degree of thoroughness of subsurface tillage and surface compaction. Another factor contributing to poor stand is the inability of conventional planting machinery to operate through the dense clumps of sod. Additional damage results to the crop stand during early cultivation because of difficulties encountered in operating conventional cultivation equipment under these conditions.

The results so far point to the necessity of developing a mulch tillage machine which is capable of separating dense vegetation from the soil mass, and at the same time thoroughly tilling and compacting the seedbed to a depth of some 4 to 8 in and incorporating therein some optimum percentage of the organic mulch.

SUMMARY

The lack of success in Virginia in using stubble mulch tools which have proved satisfactory elsewhere indicates the highly regionalized nature of the problem.

It has been adequately shown through extensive research and field experiments that the open cultivation of sloping land results in soil and water losses, the severity of which depends largely upon the slope of the land. In areas such as the limestone valleys and upland region of Virginia, in order to achieve a balanced agriculture, it is necessary to cultivate slopes of sufficient magnitude to cause severe erosion losses. It is therefore necessary to devise methods of cultivating such lands without these losses. The principle of mulch tillage, despite all of the difficulties encountered, seems to provide the best approach. It provides for continued soil protection through the use of vegetative mulches which tests have proved effective in controlling soil and water losses.

Need for Basic Science

AS A people, our strength has lain in practical application of scientific principles, rather than in original discoveries. In the past, our country has made less than its proportionate contribution to the progress of basic science. Instead, we have imported our theory from abroad and concentrated on its application to concrete and immediate problems. This was true even in the case of the atomic bomb. The basic discovery of nuclear fission was made by Otto Hahn and F. Strassman in Germany, founded on preliminary research in Italy, and published in a German periodical in January, 1939.

That free exchange of ideas which formerly permitted us to import to meet our needs no longer prevails. Europe's laboratories are still blacked out and are likely to remain so as long as the unsettled state of the world continues. In many parts of Europe, scientists have been dispersed or slaughtered, laboratories wrecked, intricate and unique equipment destroyed. In others an iron curtain has been drawn around the work of the scientists. The strong nationalism, characteristic of these times, and the isolationism of science that results is a further barrier. The unity of western civilization has been shattered, and for the first time in our history we are on our own so far as the extension of knowledge is concerned.—From a report by John R. Steelman, chairman, The President's Scientific Research Board.

Use of Strain Gages for Farm Equipment Design

By Sherman C. Heth
MEMBER A.S.A.E.

THE intent of this paper is to present the benefits possible through use of the electronic strain gages in the design and testing of farm equipment and to describe briefly some of the essential mechanics of their use.

The electronic strain gage is simply a fine piece of resistance wire mounted in an insulating medium which is cemented to a specific part. Changes in surface dimension of this part, under loading, are transmitted to the gage, and the elongation or compression of the gage wire changes its electrical conductivity. This change in resistance is read or recorded through the medium of suitable equipment. As stress (within the elastic limit) is a straight-line function of strain, or deflection, it is a simple matter to convert mathematically the varying ohmic resistance of the strain gage into exact figures on stress and strain, or deflection.

Naturally gages must be of the proper type and be mounted in the correct planes. For details on type and purposes for various applications, the literature on gages and equipment available from the Southwark Division of the Baldwin Locomotive Company is quite comprehensive.

The author's experience with these gages as a tool in designing and testing farm equipment has revealed that even the best of graphic and mathematical analyses are subject to considerable error when applied to a structure with as many strain and support redundancies as, for instance, a corn picker or combine.

Without going into a detailed discussion of specific instances, which involve details of construction and test procedure of a tedious nature, it can be stated that the use of strain gages has made possible the substantial reduction of weight in one case of nearly 20 per cent without the loss of effective strength, and in many cases have revealed high stresses of a repetitive type, which would have inevitably resulted in fatigue failures — high stresses which were not anticipated by graphic and mathematical analyses. Of course, these highly stressed parts would have been discovered during the course of extensive experimental test operation, but the use of the strain gage made feasible corrective steps at the beginning of test operations rather than at the end.

Those of you who are concerned with the design of harvesting equipment know how hazardous it is to place machines in production without a minimum of three seasons field work with test machines built exactly to production specifications. With this condition in mind, the advantages of determining structural weaknesses as soon as possible is obvious.

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1946, as a contribution of the Power and Machinery Division.

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Another advantage of the strain gage is that it can provide the engineer with exact information on loadings of the various components of machines. There is no need of amplifying the benefits of such information as it is all too apparent to all engineers.

In our first experiments with strain gages on harvesting equipment we soon learned that one of the most important factors to insure accurate readings and calibrations was the proper application of the gage itself. This meant not only the applying of the gage, but the point and conditions of application. The point of application for determination of minimum and maximum stress is in some cases obvious to the engineer; in others, the use of several gages on a single part and in various planes is advisable.

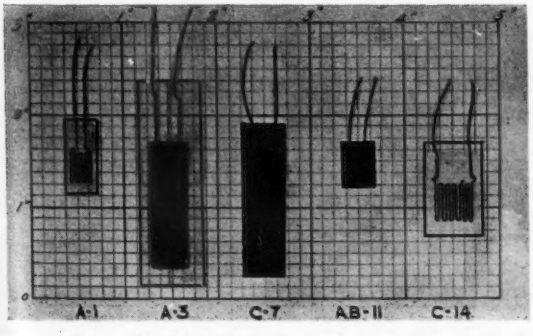
It has been determined that it is impracticable to obtain satisfactory results when mounting gages outdoors under unfavorable weather conditions such as extreme humidity and very cold weather, say, below 30F. When a condition of high humidity exists, such as 95 per cent at 80F, bond failures between gages and check surfaces are high. In one instance when the temperature was 10F, we applied 15 gages to test parts, and two gages to temperature-compensating pieces, by cleaning the application surfaces thoroughly, heating with a blow torch to drive out all moisture, recleaning with acetone and making gage application with parts cooled to approximately 60F. Out of 17 gages, only three gave satisfactory results. In all these tests we used the Southwark dynamic type C-7 gages. Possibly the A type, or so-called static stress gages, which are less sensitive to temperature changes would have been satisfactory. We have had no adverse weather experience with any except the dynamic type of gage.

Strain gages should be checked with a megohmeter after application. Unstressed gages with a reading of less than 50 megohms to ground, are, in our experience, defective and will not give reliable stress readings. Generally a properly applied gage will read in the vicinity of 200 megohms.

Gages should be protected from moisture, paint, and fumes which might affect the bond between gage and check surface. For gages to be used for only a limited time, we have found Petrosene wax a good protective agent. For gages to be checked periodically over a protracted period, a more durable protective element, such as Dow 500, one of the liquid silicones has proven to be satisfactory. This liquid is applied to a felt pad, and the pad placed over the gage. A Baldwin Southwark representative has informed us that some users have had good results with a Johns-Manville asbestile cement as a protective agent. Of course, in addition to the protective agents mentioned, gages must be shielded by a sturdy, non-contact guard, if the gage is in a position to be damaged by handling, passage of material, etc.

At present no authentic information on the solvent effect of petroleum products, paints, etc., on the glue or bonding material used for stress gages is available, as far as the author knows, however, it is anticipated that gage manufacturers will release such data shortly.

There has been some mention of temperature-compensating gages. These are gages mounted on materials similar to those



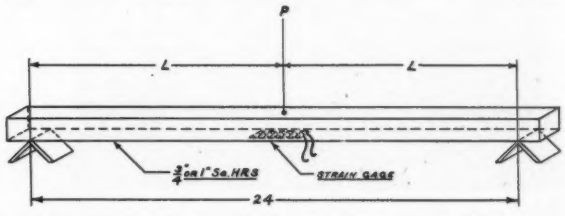


Fig. 1 (*Left*) Representative types of strain gages • Fig. 2 (*Right*) Demonstrational model strain gage used to determine weight

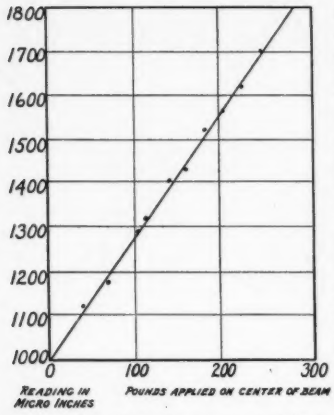


Fig. 3 This chart of stress vs. weight is plotted from a demonstration hookup of a ¾-in-square unrestrained bar with the load applied at the center, using the strain gage and associated equipment

being checked, and are electrically connected so as to compensate for the temperature contraction or expansion of the specimen being checked, so that this factor will not be interpreted as stress. For field checks of harvesting equipment, a sufficient supply of temperature-compensating gages should be utilized to take care of the various gage locations on a machine. For instance, on parts immediately adjacent to engines, a temperature-compensating gage in the immediate vicinity of the test gages is a must. Our practice has been to provide steel and grey iron test blocks, with compensating gages mounted thereon, in sufficient numbers so that stress men could tape a block in the vicinity of each group of test gages. Of course, compensating gages must be mounted on material having the same physical properties as that of the part undergoing test.

The practice we have been following to obtain as complete a data chart as practicable has been to mount gages on prime parts before assembly, and record the static no-load reading. After the machine is assembled, static readings are recorded. Gages are checked under actual field operating conditions and readings noted. At this time, any unusually high or very low stresses are analyzed, and suitable corrective steps are taken. Periodically during the season's run gages are checked, dynamically and statically, and at the end of the season the machine is disassembled and parts are rechecked statically. The complete data is then analyzed to determine weaknesses or economically unsound under-stressing, and corrective steps are taken before any further test operations.

It is difficult to determine exact stresses in welded assemblies. High temperatures close to joints preclude the possibility of applying gages prior to welding. The only solution to this problem, as far as I know, is the practice recommended by Baldwin Southwark. Gages are applied at critical points close to the welds after a welded assembly is completed, and the gage and its base are then trepanned from the assembly.

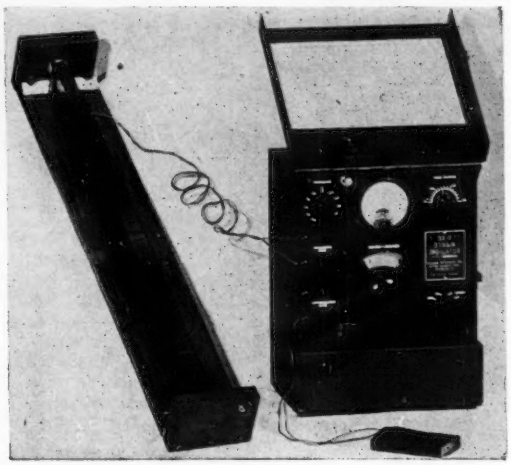


Fig. 4 This shows a strain gage hookup

The difference between the static reading before and after trepanning is a reliable indication of the residual stress induced by welding, due to the natural relieving action of the minute test slug trepanned from the whole unit. In some cases the residual stresses will be found advantageous. In others the engineer may be somewhat shocked to find how little remains of the safe stress range for actual use. Study of the results of gage trepanning on welded assemblies will be most helpful in determining finished designs.

A considerable variety of gages is available (Fig. 1). Our experience has been limited to those manufactured by the Baldwin Southwark Company. After considerable experimentation we have tentatively standardized on the A-7 gage for static work, the main reason being that its dimensions suit the greatest number of our applications most favorably,

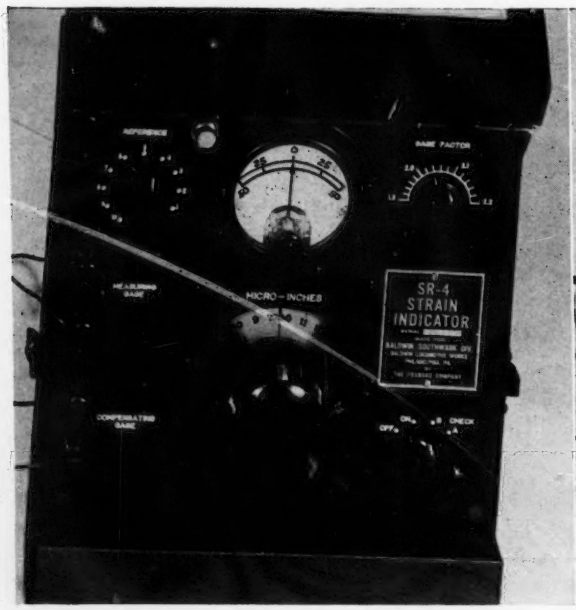


Fig. 5 *(Left)* This is an SR-4 unit balanced to null reading with no load • Fig. 6 *(Right)* The same unit as in Fig. 5 balanced to null reading with a load of 200 lb on the test bar

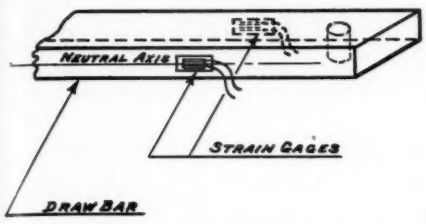


Fig. 7 A schematic application of strain gages for measuring drawbar pull

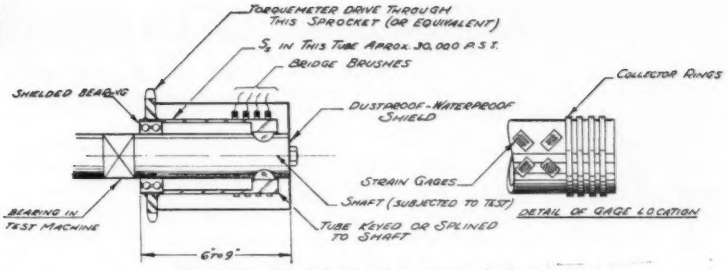


Fig. 8 Simplified sketch of a non-standard torquemeter

the gage block or pad being ¼ in long by 3/16 in wide. The type A-1 gage is popular with some users, but we have found its size objectionable when attempting to use it on edges of structural shapes. We have also tentatively standardized on the C-7 gage for dynamic measurements. Here too the size was the factor, this gage having the same dimensions as those of the A-7 unit.

GENERAL FACTORS ON USE OF GAGES FOR MULTIPLE AND TORQUE STRESSES

An interesting application of the Baldwin Southwark SR-4 indicator with its associated strain gages is the use of the unit as a means of weighing large machinery, checking weights on the drawbar, loads on each wheel, etc. All of the commercially available units required are small enough to be carried in one small suitcase.

As an illustrative example, using a pull-type combine for the subject of the test, one of these units is put under each wheel while the third is placed under the hitching point of the drawbar. The readings of the three units are alternately taken on the SR-4 indicator and recorded, and by means of a simple table, converting deflection into pounds, the weight is determined at each point in question.

For example, Fig. 2 shows the use of a demonstration strain gage mounting to determine weight. This is merely an illustration of the general scheme. A series of readings and calculations from the test unit of Fig. 2 are plotted on Fig. 3 to show the straight line relationship between stress and strain within the elastic limit.

Fig. 4 shows the strain gage equipment utilized to arrive at figures given. Fig. 5 shows the SR-4 unit balanced to null reading with no load, and Fig. 6 shows the SR-4 unit balanced to null reading with a load of 200 lb on the test bar, which illustrates the method of arriving at the figures used in calculations to determine weight, stress, or any other factor desired.

By Strength of Materials:

For a ¾-in square beam loaded at the center with unrestrained ends the greatest fiber stress is $PL/4Z$

200 lb assumed P

Length = 24 in

$Z = 1/6\, b^3$ (section modulus)

Stress at center = $PL/4Z$

$$\text{Stress} = \frac{200 \text{ lb (assumed weight on center of beam)} \times 24 \text{ in}}{4 \times 1/6 \times (3/4)^3}$$

= 17,070 lb per sq in at center of beam, at the extreme fiber

By Means of Electronic Gage SR-4:

1 The initial reading with no load was 1000 microinches to balance indicator

2 A 200-lb weight was applied to center of the ¾ sq in of beam. It was found that it took 1565 microinches of reading to bring indicator back to the null point.

3 The difference was 565 microinches of reading.

4 Using 30×10^6 as the modulus of elasticity for the steel bar, by means of the simple formula,

$S = E \times$ deflection microinches

$= 30 \times 10^6 \times 565 \times 10^{-6}$

= 16,950 lb per sq in.

5 For precision results in determining weights, the weight application must be on a "knife edge". The above readings and calculations show a difference of 120 lb per sq in, or approximately 1 per cent of the difference between theoretical and gage determined stress. This accuracy is way beyond most of the results achieved by any simple means available at the present time.

For determining pull loads, special gages may be applied directly to tractor drawbars, at a uniform section, for simplicity of calculation, and pull loads determined (Fig. 7). In order to cancel out all except tensile stresses, two or four gages could be used, on opposite sides, on the neutral axis of the section.

Charts or graphs can be made to convert the microinch strain reading into pounds, or calibrating equipment can be made to show the reading directly in pounds.

Stress gages can be utilized to great advantage in determining torque loadings. This type of work requires a so-called torque meter which is nothing more nor less than a calibrated sleeve with suitable slip ring mechanisms to pick up the varying electrical resistance from the gages mounted in an "X" direction on the sleeve to cancel out all except true torque.

On some shafts where space limitation is a deciding factor it is practical to design a torquemeter which can be mounted over the outside diameter of the shaft thereby perhaps only causing an increase of 6 to 9 in of shaft length instead of the 18 or 19 in required with a standard Baldwin Southwark unit. This type of a design will also eliminate elaborate supports, outboard bearings, and jack shaft for the drive in cases where the torquemeter would normally be coupled to the end of a shaft.

Fig. 8 is a schematic illustration of a torquemeter. These units are designed to cancel out all except torsional stress. There are specially designed units available which permit separate readings on torsion and bending. The techniques of these are involved and may be found in literature prepared by manufacturers of the test equipment.

A brief study of the mechanics of the torquemeter will acquaint any engineer with its versatility. The advantages of the electronic torquemeter are obvious. It has virtually no inertia, which plagues the engineer when using more conventional dynamometer devices, and it is relatively easy to apply to any rotating parts. Once a complete *(Continued on page 516)*

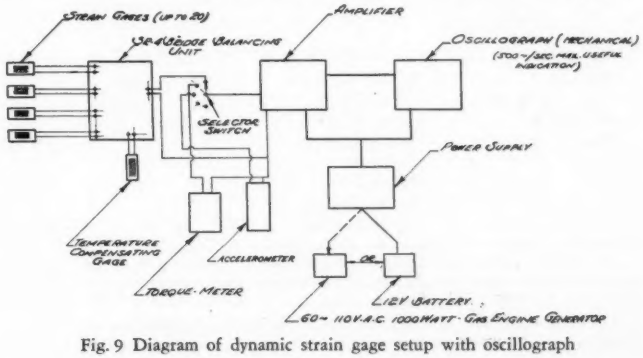


Fig. 9 Diagram of dynamic strain gage setup with oscillograph

A Discussion of Engineering Teaching

By L. M. K. Boelter
MEMBER A.S.A.E.

I. THE ENDS OF COLLEGE TRAINING; CURRICULAR AND SUBJECT MATERIAL ORGANIZATION

THE function of a university is to store, transmit, and expand knowledge. This paper will be concerned primarily with the problem of the effective transmission of knowledge to the student. Appendix I reveals clearly the setting in which the college student finds himself. The transmission process is affected by the mutual interaction of instructor and student and is conditioned by the student. The training of a student for a profession is a serious responsibility of that profession. Engineering as now practiced is both a science and an art.

Engineering as a Science. Engineering is often defined as the application of the laws of nature for the benefit of mankind. In the present period engineering instruction at a university level is strongly based on the sciences (physics, chemistry, geology, etc.) and to a lesser extent on the life sciences (physiology, psychology, sociology, etc.). The economic variable was intrenched in engineering courses a generation ago but has been set aside in later years in the more technical courses.

Offerings in a modern engineering school must reveal response to knowledge of nature which is being made available by scientific research, and engineers must immediately translate this knowledge into engineering works. A gap between the output of the scientific departments and engineering cannot be allowed to exist. To this extent an engineer is a scientist employing the data from the physical and life sciences and utilizing the scientific method to translate these data into behavior patterns of ideal systems. These systems are essentially structures, machines, processes, and circuits.

Engineering as an Art. But in the application of these systems to the world-in-being many force fields are effective which are either unknown, cannot be analyzed, or it may well prove that analysis is uneconomical. The knowledge of the professional engineer, based on scientific training but amplified by practical experience, fills the gap between the results of analysis and the actual system. Often he does not employ mathematics beyond arithmetic as a language, his modes of expression being the native tongue and the graphics (drawing). He senses the magnitudes of variables which can neither be formulated nor evaluated by the scientist. Extrapolation from system to system with reasonable assurance of acceptable results with the details unknown is indeed hazardous; the exercise of this procedure accounts for the stature of the professional engineer.

Engineering as an art is difficult to transfer. Great teachers in the professional courses are rare.

A well-balanced engineering curriculum should include courses of the scientific (analytical) and of the professional types. The ratio to be maintained depends upon external factors, for instance, upon industry requirements.

Engineering Instruction. The engineering profession may be studied functionally. A partial list of functions follows:

GROUP A	GROUP B	GROUP C
Design	Construction	Purchasing
Development	Production	Accounting
Research	Operations	Publicity
Teaching	Maintenance	
	Sales	
	Service	
	Management	
	Distribution	

Subfunctions such as repair, safety, personnel, patent law, etc., may also be cited.

A new curricular arrangement would suppress the present professional classifications (civil, chemical, electrical, mechanical, mining, agricultural, etc.), would invalidate the segregation based upon natural force fields (electric, magnetic, thermal, mechanical, etc.), and would eliminate the differences arising from the historic methods of treatment of systems as structures, machines, circuits, and process, but would be based upon function as noted under groups A, B, and C above.

At the present time some of the functions are neglected, others are included in devious ways in the courses as now constituted and therefore appear in the present curricular arrangements.

Engineering functions in group A above are those in which engineering as a science are now stressed. Those in group B are often called industrial engineering and are at the present time not always well done. Statistical techniques of analysis apply here. Also, engineering instructors have not employed to the desirable extent, the knowledge of the humanites, life sciences, and the theory of probability to these systems which are non-repetitive in character. Those functions in group C border upon business administration but often display engineering aspects.

The building of an engineering curriculum cannot be accomplished in terms of the present course offerings. A warning by Wylie[1]* must be inserted here: "They (the professors) have so departmentalized knowledge that a quadrennium is not long enough to make a sciolist, and they have let the teaching of wisdom disappear altogether from the curriculum, because, doubtless, they no longer have any to teach." "The professors got their emphasis balled up so badly that, finally, professors were de-emphasized in colleges."

The unit-operations[2] method of analysis of engineering processes is suggested as an alternative approach (to the method now in vogue) in agricultural engineering instruction. The force fields included in agricultural engineering are thermal (heat and mass transfer, thermodynamics) and dynamical (mechanics of fluids and solids, elasticity) in nature. Electric and magnetic fields play a lesser role in agricultural engineering; however, they must be utilized in precise instrumentation and must be considered in connection with power transfer and as one source of radiant energy. The primary unit-operations may be deduced by a consideration of these force fields. In addition, the operations of forming, cutting, and turning of industrial materials, transportation, adsorption, absorption, size reduction, separation, and filtration appear in the machines and apparatus with which the agricultural engineer works. Finally mensuration and instrumentation, and the properties of materials require attention. The various primary operations may each be subdivided into secondary operations. After the student has acquired experience in a number of primary operations (and the corresponding secondary operations), he should be given the experience of synthesis, namely, the application of the particular operations to a machine or a process. Exercises involving synthesis should not be delayed too long.

Agriculture is concerned primarily with the production of raw products for food (grain, fruit, meat, vegetables), for shelter (lumber, fibers), for clothing (textiles), and to a partial extent for industrial purposes (newspaper pulp, linseed and soybean oil, plastics). The unit-operations of agricultural engineering are here defined chiefly with respect to the raw material and are as follows: thermo-dynamics, heat transfer, fluid flow, mass transfer (including adsorption, absorption, and evaporation), filtration, dynamics, power transfer, size reduction, orientation, gaging, separation, transportation, and storage.

An address before the Agricultural Engineering Teaching Seminar sponsored by the American Society of Agricultural Engineers at Purdue University, Lafayette, Ind., August, 1946.

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*Superscript numbers refer to appended references.

For example, size reduction operations, in addition to cutting, are slicing, grinding, beating, chopping, rolling, crushing, and pulverizing. These operations differ in the manner in which the force is applied to the specimen and the manner in which it resists size reduction. The object of the size reduction, as well as the characteristics of the specimen, fixes the manner in which the operation is affected. With time an adequate definition for each suboperation will emerge. The suboperations listed above are probably not independent of each other.

The separation operation as applied to discreet particles is exemplified by rubbing, beating, screening, vibrating, combing, threshing, gas or liquid flotation, and sorting. The sizing operation may be thought of as either a gaging or a separation process. The production phase of agriculture (after the soil has been prepared) includes sowing, planting, thinning, hoeing, and irrigation. One secondary or suboperation of planting is gaging.

In this paper each primary unit-operation will not be discussed completely. For instance, soil plowing consists of slicing (cutting), elevating, inverting (turning), and pulverizing. The storage operation includes ensiling, piling, stacking, baling, housing, etc.; while transportation includes raking, conveying, batch hauling, lifting, etc. Another method of subdividing the operations of agricultural engineering presents tillage, seeding, harvesting, processing, irrigation, storage, and pest control as the primary operations. Thorough analysis of the results of unit-operations experiences will aid in the classification of the various primary and secondary operations.

When basic data are available on each of the unit-operations noted above and others, for the list is incomplete, then it may be said that agricultural engineering as a science has come into its own.

Superposition of unit-operations instruction upon instruction for function in terms of specific engineering systems, thus providing the experience in synthesis, will yield a satisfactory training regime.

Engineering systems as noted earlier are primarily processes, machines, circuits, and structures. The interaction of man with these engineering systems must be included as part of the subject matter. This reasoning leads naturally to the conclusion that the agricultural engineering student must have training in the life sciences, especially physiology, and psychology in addition to training in biology. Such a course properly organized would include principles of physics and chemistry and thus the time spent on these latter subjects could probably be reduced. The life science training should be placed in the sophomore (or junior) year. Appendix VI, part A, reveals an outline of knowledge which the beginning junior student should have acquired to successfully prosecute upper division work.

Currently there is much discussion of the humanistic-social stem of the training of engineering students. It is the author's considered judgment that one step in this process requires that the engineering and basic scientific courses must be humanized. A quotation from Wylie[3] is pertinent: "Whole man is not just physics and chemistry, nor yet entirely a producer and consumer of goods, but all three, and the creature of the future besides, unless he destroys the future by carrying to its ultimate end his preoccupation with the material aspect of now, alongside his denials of other kinds of time."

Appendix VI, part B, sheds further light on the author's philosophy of liberal training for engineers. The history of engineering works and the biographies of engineers naturally form a substantial part of engineering courses.

II. TEACHING

Many of the essential features of the learning process and its complement, the teaching process, have been discussed in the paper, entitled "Some Observations on Learning"[4]. In this presentation certain characteristics of teachers will be noted and discussed.

A quotation from an address by Henry Durant[5], first president of the University of California, follows: "The teacher must be a man of sympathy, communicable, a 'genial' man, one, that is, who imparts himself to his pupils along with his lessons and wins from them responses of the heart as well as of the lips. He teaches by infusion. He imitates Nature. The dews of heaven do not distill upon the plant, nor the breezes fan it, nor the rays of the sun fall upon it, to show it how to grow; they must enter into it; are assimilated to it; grow together with it, and so become a part of its very existence. Such are the relations of the teacher and his pupils. A correspondence of thought and feeling is established between them like the elective affinities among the elements of matter, or the polar attractions, in electricity and magnetism, by means of which while they are distinct and original in themselves, a new result is produced, greater and better than either alone, combining and reflecting the powers and characters of both."

LIGHT ON TEACHING FROM THE GREAT TEACHER

One may also throw some light on the teaching process by studying the greatest of all teachers. Two quotations from Papini[6] appropriately reveal the characteristics of authority, sincerity, and interpretation: "Many listened to him and followed him because, says Luke: 'His word was with authority.' The words were not wholly new, but the man was new, and new was the warmth of his voice, and the good done by that voice overflowing from his heart and going straight to the hearts of others. The accent of those words was new, and new the sense that they took in that mouth, lighted by his look.

"Suddenly the old text was transfigured, became transparent, belonged to their own times, it seemed a new truth, a discovery they had made, a discourse heard for the first time; the words withered by antiquity, dried up by repetition, took on life and color; a new sun gilded them one by one, syllable by syllable; fresh words coined at that moment, shining before their eyes like an unexpected revelation."

A student must know himself. Again the Great Teacher will be seen through the words of Wylie[7]: "Christ had powerful flashes of insight into the deep nature of man's consciousness and he used every device he could invent to try to reveal the process of that insight to those who would listen. . .

"The one, great positive idea which Christ repeatedly tried to express was the thought that no individual human being could know himself unless his inner honesty was complete. . . .

"No man, according to Christ, could know himself unless he knew all the negative and inferior aspects of himself—which is a thoroughly reasonable and scientific principle. A man, Christ also said, who did not know himself could not in any way trust what he thought about other men or the world.

"Christ, then, took the very solid position that unless you know who you are you don't know what you're thinking about, and you can only find out who you are by a difficult job of detached self-appraisal.

"Christ lived in an era when there was no Western terminology. He was compelled to try to define the principle in value-analogies and in pictures. He used pictures, largely from the industry and agriculture around him and also from the books of prophecy and rabbinical law in which he, as a rabbi, had been educated.

"The university insists upon its great value—the scientific method—and, in the flash and sizzle of high-tension laboratories, proves the merit of inductive reasoning while it denies the existence of inner evaluations upon which the same method might fruitfully be applied. By this means scientists are produced—anti-everything—convulsed with passions of negation —brilliant legions of the half-conscious.

"It is this principle of feelings as the obverse side of values with which Christ was largely concerned. He did not have a trained logic that some Western men have achieved, and when he tried to think about or define his insight in terms of thought he became confused and his disciples were utterly confused. But, within the function of feeling and values, he was neither restricted by language nor entangled in seeming paradoxes which lacked the intellectual means to unravel. Values, in A.D. 30, were extraordinarily like values today — and much of this book has been in token of fact, in reminder to the reader that material advances do not constitute any sort of improvement in people whatsoever. Christ's method of expressing and reexpressing values, as a means to true, moral

and scientific feeling, would be found to cover almost as wide a range of perceptibilities two thousand years ago as it covers now — if anybody bothered to analyze it.

"But in the book and in the man there is only this: a study of individual integration — a statement of a principle for the analysis and synthesis of inner man as old as the hills and as new as cryology. In the book and in the man there is only a science for the psyche identical with the science of physics for matter."

Paraphrasing Plato[8], Theaetus delicately reveals the role of the true teacher. . . . Those who frequent his company at first appear, some of them, quite unintelligent; but, as they go farther with their discussions, all who are favored by heaven make progress at a rate that seems surprising to others as well as to themselves. Although the many admirable truths they bring forth have been discovered by themselves from within, the delivery is heaven's work and his.

William James[9] suggests an excellent precept as the fourth maxim on education and behavior: "Don't preach too much to your pupils or abound in good talk in the abstract. Lie in wait rather for the practical opportunities, be prompt to seize those as they pass, and thus at one operation get your pupils both to think, to feel, and to do."

Alexander Pope[10] offers judicious advice relative to the tendency to learn by indirection: "Men must be taught as if you taught them not, and things unknown proposed as things forgot." He also recommends, "Be silent always when you doubt your sense; And speak, though sure, with seeming diffidence."

A teacher must exude knowledge with enthusiasm. He will wish to share his experience with others. He must be an assiduous student and particularly in breadth of general knowledge cannot yield superiority to his students.

The instructor must recognize the difference between principles and applications. His task is essentially to aid the student in formulating his (the student's) experiences. Too often instructors visualize that training consists of a myriad of applications in a specialty. To aid the student to a way of thought, a universal method of analysis and synthesis[11] must be the goal of teaching. Thus the mode of attack, the formulation of procedures, not the subject material itself becomes central.

Adaptability is one of the chief abilities of a good teacher. He must place himself in the position of the student in order to understand him. Vincent Van Gogh[12] when initiating missionary activities among the Borinage miners noted that they had accepted him after he had collected coal from the waste dumps and had not succeeded in thoroughly washing his face. In short, the teacher must be a student. By casual observations and the study of reports and problem sets the instructor must sense the thought processes of the student. A recognition of the method of approach employed by individual students to problem solution is essential to effective teaching.

Exact knowledge of the laws of learning[4] will prove a great aid to the teacher. He must formulate these principles for the student in order to reduce learning impedance to a minimum. The instructor must be capable of objective judgment and be tolerant of ideas and behavior. Above all he must be capable of self-analysis. Appendix III, IV, and V reveal charts for colleague evaluation, self-evaluation, and student evaluation, respectively. These charts are not complete, but the results will serve as a guide to the earnest teacher, who seeks the counsel of his colleagues and his students.

APPENDIX I. WHAT THE UNIVERSITY AIMS TO GIVE THE STUDENT[13]

A modern university is rather a poor mechanism for giving anything to a student which he does not reach for. Indeed, it is a question whether a student ever really gets anything he does not take. A university sets a pretty good table, but does not guarantee either an appetite or a digestion. The education which a man gets which will really count must involve a change in himself — in his character and being. A university has at its disposal no alchemy by which brass can be turned into gold. The gilt form of education wears out very soon and is worse than nothing. The university constitutes for the student an opportunity of entering in and making the most possible out of himself.

It proposes to rescue men from slavery and make them free, in case they want to be free. It proposes in the first place to make them free from the bondage of prejudice, routine, and the rule of thumb. A freeman is a man who can initiate, who has sufficient control over his walks and ways to do as his reason and outlook tell him is right and best. A man who acts on a prejudice, or drives his wagon in other ruts is a slave, no matter how much he may pride himself on his prejudices and loyal adherences. The whole purpose of the university is to provide men with the means of seeing into things themselves, so that they shall not be dependent, but independent. The university proposes to give the student such insight into the facts and the way of determining the facts as will put him in a position of control over some field of knowledge or human activity in which he is to exercise his being for the good of those about him.

Thirdly, the university aims to give the student the highest and best form of control of himself. Unless a man finds himself and finds out how to get a grip on himself, so as to be able at times to shake himself, he is not educated.

The method by which the university proposes to give these things to its students is in substance the one simple old-fashioned method of the transference of life. The university is essentially a society of scholars working together. The leaders inspire their followers; the older guide the younger. The best thing the university can give to its students and the thing that includes all others is the inspiration to noble and useful living.

APPENDIX II. EXCERPTS FROM "THE PHILOSOPHY OF WILLIAM JAMES"[9] (CHAPTER VII) EDUCATION AND BEHAVIOR

1 Education in short, cannot be better described than by calling it the organization of acquired habits of conduct and tendencies to behavior (p. 269).

2 No reception without reaction, no impression without correlative expression — this is the great maxim which the teacher ought never to forget (p. 272).

3 To quote my earlier book directly, the great thing in all education is to make our nervous system our ally instead of our enemy. It is to fund and capitalize our acquisitions, and live at ease upon the interest of the fund. For this we must make automatic and habitual, as early as possible, as many useful actions as we can, and carefully guard against the growing into ways that are likely to be disadvantageous (p. 276-277).

4 The second maxim is: Never suffer an exception to occur till the new habit is securely rooted in your life.

5 A third maxim may be added to the preceding pair: Seize the first possible opportunity to act on every resolution you make, and on every emotional prompting you may experience in the direction of the habits you aspire to gain (p. 279).

6 This leads to a fourth maxim. Don't preach too much to your pupils or abound in good talk in the abstract. Lie in wait rather for the practical opportunities, be prompt to seize those as they pass, and thus at one operation get your pupils both to think, to feel, and to do (p. 280).

7 . . . as a fifth and final practical maxim about habits, offer something like this: Keep the faculty of effort alive in you by a little gratuitous exercise every day. That is, be systematically heroic in little unnecessary points, do every day or two something for no other reason than its difficulty (p. 284).

The Ideal College Education

8 Of what use is a college training? . . . The best claim that a college education can possibly make on your respect, the best thing it can aspire to accomplish for you, is this: that it should help you to know a good man when you see him (p. 287).

9 Such words are vague and such ideas are inadequate, but their meaning is unmistakable. What the colleges — teaching humanities by example which may be special, but which must be typical and pregnant — should at least try to give us, is a general sense of what, under the various disguises, *superiority* has always signified and may still signify. The feeling for a good human job anywhere, the admiration of the really admirable, the disesteem of what is cheap and trashy and impermanent — this is what we call the critical sense, the sense for ideal values. It is the better part of what men know as wisdom (p. 289).

APPENDIX III. COLLEGE EVALUATION[14]

(Check the most appropriate word (phrase, descriptive statement) in each of the following categories. Use space to the left to qualify or to explain your judgment.)

1 *Grasp of Subject*
- Excellent
- Good
- Fair
- Poor

2 *Attitude Toward Teaching*
- Excellent (Gives much thought to the technique of teaching)
- Good (Appreciates importance of teaching and gives it some attention)

Fair (Seems quite unconcerned about importance of teaching)
Poor (Regards whole business of teaching as tiresome routine)

3 *Success in Arousing Interest in His Subject*
Excellent (Highly stimulating and arouses interest generally)
Good (Usually more stmulating to students already interested in subject)
Fair (Only occasionally stimulating)
Poor (Fails to arouse interest)

4 *Success in Relating His Subject to Other Fields*
Excellent (Relates it intentionally and effectively)
Good (Relates it incidentally but effectively when undertaken)
Fair (Makes haphazard attempts at relating it and not very successfully)
Poor (Ignores possibilities of relating it)

5 *Success in Using Teaching to Stimulate Thinking*
(a) *By means of discussion*
Excellent (Organizes discussion and handles it skillfully)
Good (Does not seek discussion but handles well what arises)
Fair (Ill at ease in discussion and seeks to avoid it)
Poor (Ignores value of discussion and represses it)
(b) *By means of lectures*
Excellent (Aims at stimulating independent thought)
Good (Aims at sending student afield for further reading discussion and inquiry)
Fair
Poor (Barest factual presentation without interpretation)

6 *Success in Conducting Recitation*
Excellent (Elicits greatest amount of relevant information from student work)
Good (Handles recitations well and with sound time-economy)
Fair (Undependable in clarity and time-economy)
Poor (Vague in explanations, time ineffectively utilized)

7 *Success in Classroom Technique*
(a) *Poise in class*
Excellent (Self-control and control of class situation; composure; ease of manner, absence of unpleasant mannerisms)
Good
Fair
Poor
(b) *Oral presentation of material*
Excellent (Clear, definite, forceful)
Good (Clear and definite, but somewhat mechanical)
Fair (Undependable in clarity and definiteness from one class period to another)
Poor (Involved, indefinite, unimpressive)
(c) *Use of textbooks*
Excellent (Personal presentation stands out as illuminating textbook)
Good (Maintains a sense of balance betwen personal presentation and use of textbook)
Fair (Textbook usually gets upper hand)
Poor (Depends wholly on textbook)

8 *Attitude Toward Student Difficulties With Subject*
Excellent (Comprehending and very liberal with explanations)
Good (Comprehending but inclined to be brief and summary in explanations)
Fair (Slow to appreciate and fumbling in explanations)
Poor (Ignores and refuses to deal with them)

9 *General Attitude Toward Students*
Excellent (Uniformity courteous, sympathetic, approachable)
Good (Has the above qualities but less spontaneously so)
Fair (Variable and erratic in attitude)
Poor (Antagonizes students)

10 *Grading of Papers, Tests, Examinations in General*
Excellent (Regarded as uniformly fair and impartial)
Good (Regarded as usually fair and impartial)
Fair (Fairness and impartiality regarded as variable quantities)
Poor (Regarded as definitely partial and unfair)

11 *Composite Rating as Teacher*
Excellent
Good
Fair
Fair

For purpose of information, but not for inclusion in the above rating, will you kindly express an opinion on the preferable placing of person under discussion in the university teaching scheme? Place a check opposite description that most nearly expresses your judgment.

..... Good teacher wherever placed.
..... Definitely better in upper division.
..... Definitely better in lower division.
..... Ought not to teach in upper division.
..... Ought not to teach in lower division.
..... Especially adapted to teach large sections.
..... Ought to teach only graduate courses.
..... Should be assigned minimum of teaching and be employed in other function.

(Signed).....

APPENDIX IV

Part 1. Self-Evaluation as a Teacher[14]

1 Pedagogical contributions to each of the several assigned courses.
2 Revisions of course content.
3 Contributions of subject material to the course.
4 Frequency of revision of course content, notes, etc.
5 List of the syllabuses, course notes, textbook, problem sets, etc., which have been prepared. (Exhibits should accompany this item.)
6 Techniques employed to stimulate student interest.
7 Methods of instruction employed and the reasons for their use.
8 Time spent preparing for instruction. (NOTE: You may wish to include a complete weekly time schedule.)
9 Program of serious reading.
10 Extrauniversity interests and accomplishments.
11 Professional accomplishments.
12 Research bibliography. (Exhibits should accompany this item.)

Part 2. Evaluation of Teaching Effectiveness Based on Student Performance

1 The practice of inviting instructors of other courses or in related fields to write the final examination is recommended.
2 The practice of giving same examination in the various sections of a particular course should be utilized whenever practicable.
3 The examination results, so obtained after proper evaluation, may be used as a gauge of the effectiveness of teaching.

To aid in the evaluation process (and to help students and instructors to find a mutual working plane) an evaluation examination should be given at the beginning of each course.

APPENDIX V[14, 15]

Student Reaction

Instructor..... Course.....

(NOTE: The last column, headed "X", is to be used for marking questions which you do not feel competent to grade or which are not pertinent to the course.)

	Excellent	Good	Fair	Poor	X
1 Does the instructor appear to possess a mastery of the subject?					
2 Has the instructor made the aims of the course clear?					
3 Has the material been presented in such a way as to attain those aims?					
4 Has his course given you the opportunity to obtain a well-organized body of information or ideas?					
5 Has he aroused your intellectual curiosity?					
6 Has his course encouraged critical mindedness?					
7 Has he given you a desire to explore further problems in the field?					
8 Does he explain diverse points of view fairly and objectively?					
9 Has he made the course valuable as a background for further study?					
10 Does he encourage student participation whenever possible?					
11 Does he impress you as being fair in grading?					
12 Does he speak clearly and distinctly?					
13 Is his manner of speaking effective?					
14 Is his use of language effective?					
15 Does he have a sense of humor?					
16 Would you like to know him better?					

General Comments and Summary Evaluations

APPENDIX VI

To what extent should candidates for the Junior year in engineering have a background of liberal studies?[16]

A — At the beginning of the third college year, the engineering student, in the curriculums now in vogue in most four-year engineering colleges, should be proficient in three modes of expression:

(a) Native language, written and spoken word
(b) Pictorial, freehand and mechanical drawing
(c) Mathematical, arithmetic, algebraic, and geometric.

Further, he should be thoroughly grounded in:

(a) Laws of ideal physical systems (now presented in chemistry, physics, and geology courses)
(b) Properties of materials
(c) Techniques of mensuration.

In summary, he should breathe, speak, and write the experimental basis of knowledge. Additionally, it is desirable that the third-year engineering student have available:

(a) *In the skills*
  (1) One or more foreign languages probably chosen from French, German, Russian, Japanese, Chinese, Spanish
  (2) Manual skills — for example, typing, woodworking, metal forming, repair, welding, circuit design, or others.
(b) *In the life sciences*
  (1) Basic physiological and psychological laws, particularly the applications of physical laws to animate objects.
(c) *In the humanities*
  (1) Basic economic laws, the impact of nature and man's recreation of nature on man
  (2) History as a continuous succession of events, problems, and their solutions
  (3) Literature, as posing human problems and their solutions.

These experiences when added to those which every member of society should possess, must be completed during the period which the student spends in the secondary school, high school, and in the first two years of college.

B — In parallel with this training schedule, there must be carried a professional stem, beginning in the freshman year of college. This stem can be defended on several grounds, such as application, orientation, and fulfillment of student interest. The senior program must include some courses which synthesize the student's earlier educational experiences. These courses should lean heavily on the student's earlier extratechnical training.

In the engineering curriculums, flow of knowledge exists, on the one hand, from the sciences, and, on the other hand, from the field. No gap can exist on either side. The latter flow, experimental data from the field, must be systematized and formulated into a logical sequence and more often than not cannot be mathematically (arithmetically or algebraically) expressed. The acid test of adequate formulation are clarity and brevity. This task of formulation continuously faces the teachers in the engineering curricumums.

The student in engineering then experiences formulated illustrations of basic laws, at least in some of his professional courses, rather than a mass of grossly organized experimental data. Liberization of curriculums may be defined as humanizing knowledge: first, recognition of the principle that knowledge is catalogued in several overlapping modes — for example, in literature, the social sciences, life sciences, physical sciences; second, the application of this principle by the teacher who is presenting the materials of the profession. Collegiate engineering training implies the synthesis of the underlying sciences and the art of the profession.

The teacher is central to the process of liberalization. Professional courses and curriculums can and must be liberalized by the faculties concerned. Liberal thinking on the part of the student will not result from the prescription of isolated courses consisting of compartmentalized segments of knowledge in the humanities and liberal arts. The instructors in engineering courses must set the stage and, by example, reveal the values of liberal thinking and experiences to students and the practicing professionals who, more often than not, are strict utilitarians.

The student at commencement should know himself, his limitations, and possess the will to continue his intellectual growth. Upon satisfactory performance he will be admitted to the ranks of the profession after some ten to fifteen years of service.

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Strain Gages in Farm Equipment Design

(Continued from page 511)

survey is made on torques involved in all the numerous rotating parts on farm equipment in actual use under a sufficient variety of conditions, the designing engineer will have the necessary data available for precise and economically sound design of drives, shafts, bearings, and various associated parts.

When a torquemeter was considered for our work in harvest equipment engineering, we decided on two meters — one to be from 0 to 2500 in-lb, and the other from 2500 to 5000 in-lb. The larger unit could not be expected to be sufficiently sensitive for small loads.

For static tests, the Baldwin Southwark SR-4 unit, a relatively low cost instrument which is simply a galvanic meter with suitable variable resistor devices, etc., is entirely satisfactory and gives very reliable and accurate results. For dynamic work, the same unit is reasonably satisfactory for determining peak and average loads by the trial method, providing fluctuations in loading are not too rapid and violent.

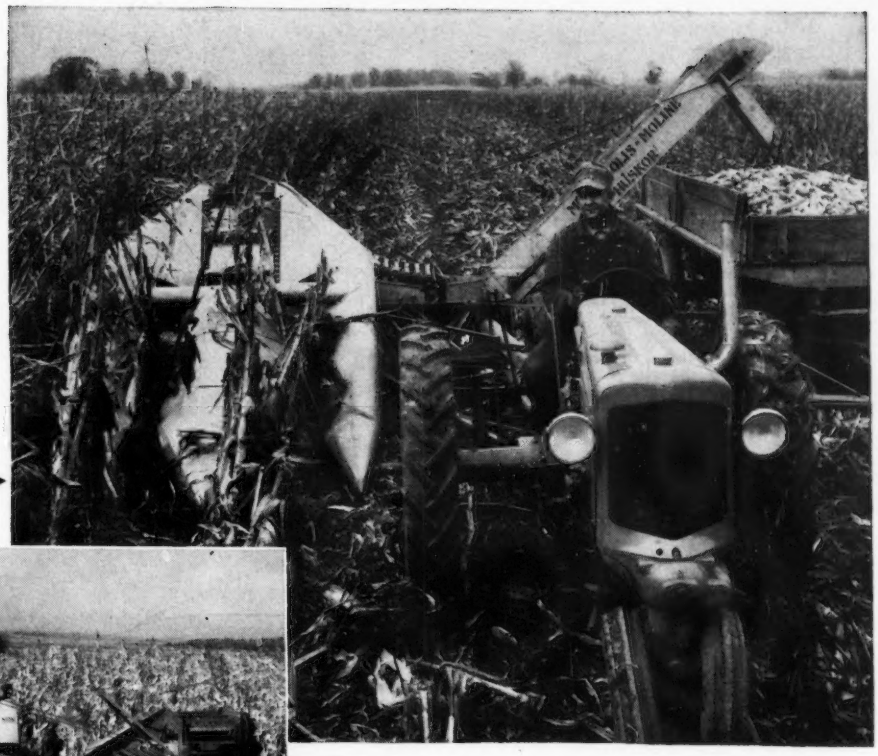
For exact determination and recording of dynamic loads, an oscillographic recorder is advisable. This with its associated equipment could be mounted in a trailer or truck — being well cushioned, of course — and used in both field and laboratory. For exact details reference should be made to suppliers' catalogues. No details on recording and calibration mechanics are indicated as these are too complicated to fall within the scope of this paper.

A 20-channel switching unit is commercially available. This unit may be used with static or dynamic types of gages. With this unit up to 20 gages can be balanced and individually switched into the indicator unit. This is a worth-while time-saving device when a multiplicity of gages are used and frequent checks are made.

Our experience has been that use of equipment of the type described should be limited to a small group of engineers, specifically trained in its use, if accurate, reliable results are to be obtained. Fig. 9 shows complete dynamic strain gage recording installation.

The foregoing is intended merely as a brief presentation of an engineering tool. Its advantages, as with any tool of this nature, depend on intelligent application and analysis of results. It is not a low cost tool. An installation for static and limited dynamic use on a non-rotating structure will cost approximately $1500. An installation, including torquemeters and an oscillographic recording device will run about $15,000. The cost, however, is small compared with the possible benefits to any except a very small engineering division.

In the Minneapolis-Moline "Huskor" the vital functions of gathering, conveying, and power transmission are performed by Steel Link-Belt. Link-Belt Silverlink roller chain is used for high speed power transmission.



Dependable CHAINS . .

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RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

THE second National Farm Electrification Conference held at Indianapolis, October 7 and 8, brought together approximately 300 representatives of manufacturers, power suppliers, farmers, electrical wholesalers and retailers, editors of farm papers and electrical trade papers, and federal and state research workers. With the object of exploring problems in research directed toward making electricity handle more farm jobs better, conference speakers focused attention on a number of specific points which can stimulate the planning of agricultural engineers.

The jobs of getting electric service to more farms, increasing the capacity of farm lines, and improving the quality and dependability of farm electric service were outside the scope of this conference. Considerable attention was given, however, to the importance of adequate farm wiring — subject of one of the panel discussions. New farm users of electricity must be impressed with the need to have their initial wiring job carefully done and carefully planned to take care of later expanded use.

Adequacy of wiring was also stressed in the panel discussion on distribution and servicing of farm electrical equipment. It was recognized that special attention to farmers' needs should be given all along the line, beginning with the manufacture of truly serviceable equipment and including special training of the men who sell and service the equipment. Education was seen as an important part of the picture.

Of most interest to engineers, however, was the session of the conference devoted to "Farm and Home Uses, Experimental and Research Work and Unfilled Farm Electric Equipment Needs." A resume of the pertinent research projects at state experiment stations indicated that four states (California, Colorado, Montana, and Nebraska) are working on electricity in relation to irrigation and drainage. California, Massachusetts, and Michigan are investigating protection from frost damage. Twenty-one states are active in forage and grain drying, curing, and storage problems; nineteen have projects on time-and-labor-saving equipment; and seventeen are concerned with curing and preserving perishable farm products under controlled conditions.

Dramatic research possibilities lie in the field of devising means of applying to farm production the diversified powers of electronics, supersonics, and radioactivity. Important missing links in the chain of scientific knowledge now being applied to agriculture were pointed out by B. C. Reynolds, agricultural engineer of the USDA Office of Experiment Stations. "What," he cited as an example, "are the basic and fundamental principles which cause forages and grains to dry? Do these materials dry from the inside out or from the outside in? What do we do to the nutritive value of such forages and grains when we attempt to condition them by this method? What is the effect or is there any effect of the stage of maturity when harvested on the ease or difficulty of making this material give up its moisture?"

"Agricultural engineers," said Mr. Reynolds, "can help in the gathering of such knowledge, but because of the complicated linkage of the problem, it must of necessity be a cooperative undertaking wherein scientists trained in the fields of soils, agronomy, plant physiology, chemistry, physics, and nutrition must contribute to a full understanding of the intricate processes."

* * * *

Geo. D. Clyde, of Logan, Utah, chief of the irrigation and water conservation division, Soil Conservation Service, USDA, told members and guests of the Washington (D.C.) Section of A.S.A.E. at their October 10 luncheon meeting that the resources of soil and water on which western agriculture depends are limited resources which must be used more efficiently if they are to remain adequate. Of the 30 million acres now under the ditch, 20 million are actually being used for agricultural production by irrigation. About 30 million people depend on irrigation directly or indirectly for their livelihood. Only 10 million acres remain which can, at great cost, be irrigated.

Scientists and engineers must work constantly on ways to get a greater degree of benefit from the bringing of water to soil. Only 25 per cent of irrigatiaon water now gets to the roots of the plants. Fifty per cent is wasted in getting to the field and 25 per cent is wasted in the soil. Mr. Clyde believes that this loss can be cut down greatly as we learn more about the properties of soils and waters and about how water moves through soil.

Irrigation engineers need to develop a more accurate and practical method of determining soil moisture content. There is still no way of knowing scientifically when an irrigation is complete. Technical data are lacking on which to base time and amount of water application for specific crops under varying seasonal conditions. A great deal of progress has been made in measuring snow storage and predicting peak flows, so that water users can plan their operations accordingly, but much remains to be done.

Irrigation can be made to sustain a successful agriculture down through the years, Mr. Clyde believes, but there must be constant effort to increase our detailed scientific knowledge of the physical and chemical processes involved. This knowledge must then be implemented, of course, by true, long-range "beneficial use."

* * * *

USDA agricultural engineers at Ames, Iowa, Urbana, Ill., and Lafayette, Ind., are taking delivery this month and next on seven farm-size ear corn driers ordered for experimental and demonstration work in the corn belt under the Research and Marketing Act. The driers are being built to specifications based on results of experimental work which agricultural engineers of the Department and cooperating state stations have conducted for a number of years. They are portable types which can easily be moved from one farm to another and will be used on farms in those areas where the soft corn problem is most acute.

Designed to use air heated to a temperature up to 70 F higher than the atmospheric temperature, the smaller units will be suited for drying cribs containing 900 to 1,500 bushels of corn and the larger ones for cribs containing 1,500 to 2,500 bushels. Time required for drying will depend on the amount of corn in the crib, its moisture content, uniformity of air flow through the corn, weather conditions, and the size of drier used. Each of the units is expected, however, to dry a specified amount of corn in from two to seven days.

The corn driers ordered include two oil-burning types for direct heat, one 5 hp and one 3 hp, from the American Crop Drier Corp., Crystal Lake, Ill.; one 3 hp and one 5 hp oil-burning drier for indirect heat from the Habco Mfg. Co., Columbus, Nebr.; two units, one a 3 hp bottled-gas-burning drier and the other a 3 hp solid-fuel, hand-fired unit from the Campbell Dryer Co., Des Moines, Ia., and one 3 hp solid-fuel stoker-fired drier from the Dominion Engineering Co., Arlington, Va. The blowers are electric or engine-operated or both.

* * * *

On September 22 to 23 an industry research conference for the Agricultural Committee of the American Petroleum Institute was held at the Agricultural Research Center, Beltsville, Md. The group was welcomed by Undersecretary of Agriculture N. E. Dodd, who compared progress in mechanization in this country with that of other countries and stated that one reason we are so far ahead is the advancement made by the oil industry. Dr. Stanley B. Fracker outlined the organization of the Agricultural Research Administration and called attention to some of the leading accomplishments of its six bureaus. Dr. Trullinger detailed the operations of the Office of Experiment Stations.

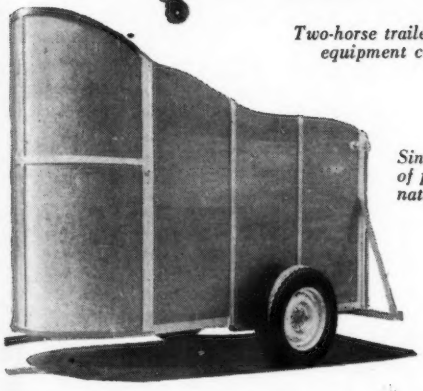
At the Agricultural Engineering Laboratory, R. B. Gray, chief of farm machinery, explained that the work of his division is divided into ten projects, four of which are applicable to a number of crops and six of which are specific. A weed control project to be started soon will be cooperative with states and other divisions in the Bureau. Engineer David Isler, who spends most of his time at the Toledo pest and plant disease control station, told of cooperative research on physical properties of new insecticides, effective equipment for uniform application, airplane spraying and dusting, etc.

Glenn A. Cumings, in charge of fertilizer placement work, described recent progress on engineering to put the plant food where it will do the most good. Avoiding excessive corrosion in the machine is part of this complex problem. Recent studies include work with liquid fertilizers and with plow-sole and subsoil placement. Side-band placement has been found to have the advantages of getting the material into moist soil, allowing less fixation of phosphorus, and keeping the fertilizer out of the direct line of tender developing roots. Fertilizer consumption has practically doubled within the last 8 or 10 years, and the amounts applied per acre are increasing rapidly. The number of manufacturers increased from 100 to 150 in the last few years and with consumption now over 15 billion pounds annually the industry returns about two billion dollars.

George R. Boyd told the visitors that his division, mechanical processing of farm products, tries to put farm products in shape to bring the farmer a better price. The flax industry was built up during the war from 4,000 to 18,000 acres to supply the linen thread we needed. Equipment brought from Europe did not find favor with American workers and managers, who have eagerly received agricultural engineers' help on improved techniques. The present high price of jute from India increases the chances of establishing kenif as a substitute fiber. Mr. Boyd also pointed out that a problem in cotton mechanization is reorganization of the farms—consolidation of fields to make possible efficient use of machines.

The Monday afternoon session of the conference included brief talks on electrical energy in agriculture by Truman E. Hienton, new techniques in curing tobacco by O. A. Brown, and hay-drying equipment by L. G. Schoenleber. Various aspects of farm structures research were discussed by Wallace Ashby, J. R. McCalmont, and J. R. Dodge. Frank Teuton of the Bureau of Agricultural and Industrial Chemistry spoke on chemistry and agriculture. *(Continued on page 524)*

Two-horse trailer de luxe, with equipment compartment



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Interior view of stables at Fairway Farm, Medina, Washington

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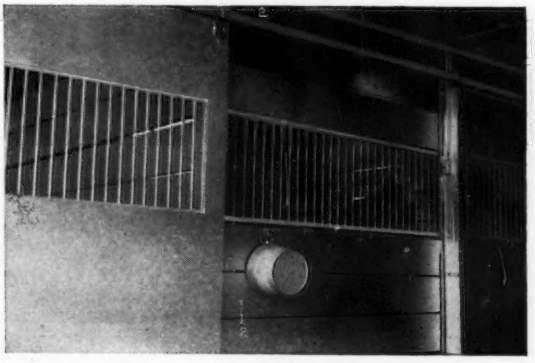

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Agricultural Engineering Institute Dedicated in Hawaii

DEDICATION of the Agricultural Engineering Institnte at the University of Hawaii, September 5, marked a new step forward in the progressive agriculture of the Territory. The ceremonies featured an address by H. B. Walker, professor of agricultural engineering, University of California, and the official opening of new building and research facilities for the Institute.

The Institute was initiated through the joint efforts of the University, the Hawaiian Sugar Planters' Association, and the Pineapple Research Institute. It is to be administered as a department of the University of Hawaii and its agricultural experiment station. The administration will provide for university instruction, for close contact between personnel of the associated organizations, and for mutual use of research facilities in the interest of expediting results.

New additions to the existing physical plant include a combined administration building and machinery laboratory and a separate shop for storage and repair of machinery used on the University farm. They provide comfortable year-round working conditions, excellent lighting, electric wiring for heavy equipment, and reinforced concrete floors.

E. J. Stirniman is in charge of agricultural engineering research for the Hawaiian Sugar Planters' Association, and E. G. McKibben for the Pineapple Research Institute. Rene Guillou heads agricultural engineering research and instruction in the University of Hawaii, and has been named to administer the Institute. Professor Walker was active in bringing about its establishment.

In his address, Professor Walker emphasized the economic and social significance and obligations of the Institute, in part as follows:

"I visualize in this structure opportunities for the young men and women of these beautiful islands who desire to enlarge their usefulness in the field of productive agriculture. I can likewise see within the walls of this structufe opportunities for engineers to translate scientific principles into activities of direct benefit to rural people. The usefulness of the Institute will be greatest no doubt to those who live in this immediate area. This is as it should be. But the University of Hawaii is a recogniized cultural and scientific outpost for our nation between the peoples of the East and the West, so this Institute we dedicate today must strengthen the University in meeting its broader obligations to society. . . .

"These words, 'agriculture' and 'engineering' used together, identify the Institute we are dedicating today. I would not have you think these words so used lessen the importance of either; but rather, when used in combination, they identify a field of service to an industry which in itself is agriculture. Thus engineering, as such, is an adjunct to agriculture, but its importance in technical service is increased rather than diminished by this assignment. . . .

"We must admit, when so few of our population relatively are needed to produce crops, that modern farming is no longer a mode of life. Agriculture has joined the industrial class. But it remains a distinctive industry, responsive to the scientific approach. It is an industry which, if properly managed. is restorative in its production cycles, and thus under intelligent management there need not be serious depletion of the basic soil resources upon which it depends. In agriculture the materials and resources of nature are utilized in the production of crops of direct benefit to man. To use these effectively both the biological and physical sciences may be utilized to advantage. To obtain maximum benefits from these sciences, combinations of agricultural and engineering techniques naturally develop.

"In a sense, the farm, the plantation, and the ranch, are factories in the field, where power and labor costs often make up a large part of the cost of the products marketed. But here the products are developed as raw materials; the power must be taken to the work in mobile units, and the operations must be timed to meet the habits of the plants and animals produced, and modified to meet climatic environments. Many of these operations are basically engineering in character, yet the measure of proficiency in these engineering applications must be evaluated in the end by biological responses, such as tons of sugar, bushels of wheat, pounds of beef, or dozens of eggs. . . .

"Let us hope that the Agricultural Engineering Institute of the University of Hawaii will become a common meeting ground for scientists, agriculturists and engineers. And likewise may we hope that the engineers whose major activities will be in this building will seek the laboratories of the agriculturists as well as those in related scientific fields in order that the frontiers of knowledge may be expanded constantly, and new findings translated into applications for the benefit of society. The integration of this Institute into the fabric of the University is, therefore, an essential condition for its success. It is a dependent institution and not an independent one. It cannot operate efficiently by itself. . . .

"Our universities are the pride of our respective commonwealths. We have a right to expect of them both idealism and realism. They are expected to set the patterns for cultural and scientific development, and they should not be indifferent to the everchanging social and economic patterns of the commonwealth which created them. The public will expect this Institute, located on this university campus, to serve effectively in filling out this larger university pattern for public service.

"Applied science has worked miracles for mankind; it has contributed much to human comfort and enjoyment. It has been, and continues to be, an effective tool in contributing to human plenty and to rewards for human industry. . . .

"Science, in itself, does not reason; it has no soul; and it does not understand social justice. Fortunately, it is not subject to monopoly where men are permitted to think independently and are free to act in a truly democratic society. Most of the products of engineering skill, while based upon the inimitable laws of nature, are inanimate things, capable of use for good or evil depending upon the thoughts and subsequent actions of those who foster their development and use. This Institute will deal largely with material things such as machines and appliances designed to reduce human effort and costs in the production of essential commodities needed by people. . . . But men will always be needed to control these machines through the exercise of skill coming from a trained intellect. Brawn is less appreciated today, and intelligence and skill become virtues. This adds dignity to labor. The training of men and women for such responsibilities in agriculture is to become one of the most important functions of this Institute. . . ."

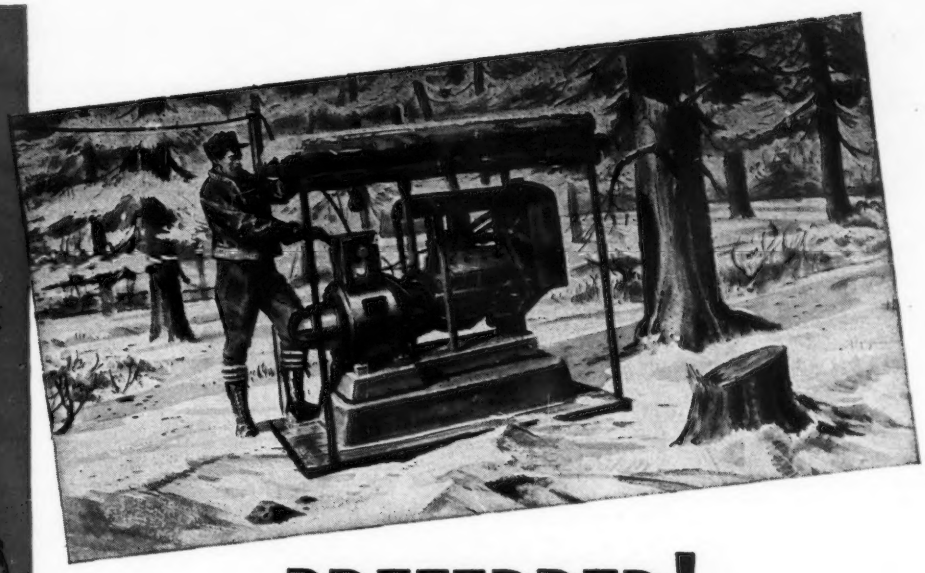
Agricultural Engineering Activities in India

NEW agricultural engineering activities of the Allahabad Agricultural Institute, Allahabad, India, as reported by Mason Vaugh, chief agricultural engineer of the Institute, includes a survey for the Food and Agriculture Organization of UN of small implements and tools used in Indian agriculture. It will cover a period of about four months and is being made as a test survey of the central part of the Ganges Valley. This survey will incidentally give information about agricultural practices in the area as well as implements and tools.

The Institute has a minor research project now being carried out to develop a milk-dispensing device to make possible bulk delivery of milk, at the same time making impossible adulteration of the milk in the can from which it is dispensed. This is necessitated by the prevailing custom of adulterating milk and the fact that prices will not justify the cost of bottled milk delivery.

The Institute recently submitted to the United Provinces Government an extensive program of research including testing and developing work on a combined harvester-thresher, particularly with respect to saving and utilizing the straw.

Left: This is a view of the administration building and the machinery laboratory of the Agricultural Engineering Institute at the University of Hawaii • *Right:* A closeup of the Institute's machinery laboratory



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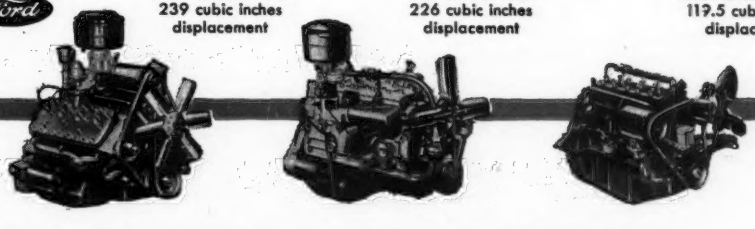

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NEWS SECTION

A.S.A.E. Winter Meeting Program

THE Winter Meeting of the American Society of Agricultural Engineers will be held at the Stevens Hotel in Chicago, December 15 to 17. For the most part the program is arranged by the four technical divisions—Power and Machinery, Rural Electric, Farm Structures, and Soil and Water. The program in chronological order follows:

FORENOON, MONDAY, DECEMBER 15

There will be three concurrent programs presented during this period, as follows:

Rural Electric Program. The topic for this program is "New Developments in Farm Wiring". A paper on the use and limitations of aluminum conductors will be given by Howard H. Weber, United States Rubber Co. Glenn Rowell, Fire Underwriters Inspection Bureau, will discuss non-metallic sheathed cable in farm installations, and D. C. Sprague, Pennsylvania State College, will talk on a one-week short course in farm wiring for agricultural leaders.

Soil and Water Program. The program will deal largely with the subject of drainage, with the addition of one paper on irrigation. The drainage papers include one on durability of drain tile by P. W. Manson, University of Minnesota; one on concrete farm drain tile by W. G. Kaiser, Portland Cement Assn., and a third on the double-drained ditch for fields planted to row crops by John M. Downing, U. S. Soil Conservation Service. At this session J. R. Carreker and M. J. Liddell, U. S. Soil Conservation Service, will report on their work in supplemental irrigation in Georgia.

Fertilizer Application Program. This program, details of which will be found elsewhere in this issue, is being arranged by the National Joint Committee on Fertilizer Application, which is comprised of representatives of the American Society of Agronomy, American Society for Horticultural Science, National Fertilizer Assn., Farm Equipment Institute, and American Society of Agricultural Engineers. The National Joint Committee extends a cordial invitation to A.S.A.E. members and others interested to attend the two sessions at which its program will be presented.

AFTERNOON, MONDAY, DECEMBER 15

Rural Electric Program. A motion picture presentation of mechanization of the poultry industry by D. G. Womeldorff, Public Service Co. of Northern Illinois will open this program, which will be followed by a progress report on farm work simplification projects by Paul R. Hoff, Cornell University. Two papers are also scheduled: Electrical controls for efficient use of equipment by B. P. Hess, Westinghouse Electric Corp., and a new automatic egg washer and drier by F. B. Wright, Cornell University.

Soil and Water Program. Three papers: Conservation and upstream flood control by John S. Glass, U. S. Soil Conservation Service, soil mechanics of small earth dams by R. B. Peck, University of Illinois, and flood routing in the design of spillways for small earth dams by M. M. Culp, U. S. Soil Conservation Service.

Fertilizer Application Program. (See separate item on program elsewhere in this issue.)

EVENING, MONDAY, DECEMBER 15

Rural Electric Program. The topic is uses of radiation in agriculture, with three papers as follows: High-frequency sources and their fundamentals" by A. T. Lattanzeo, Westinghouse Electric Corp., radiation from electric lamps sources by J. P. Ditchman, General Electric Co., and agricultural needs and applications of radiation by J. E. Nicholas, Pennsylvania State College.

FORENOON, TUESDAY, DECEMBER 16

Power and Machinery Program. Panel discussion of the topic: "Flexible Power Transmission for Farm Machines—What Shall We Use?" Speakers who will talk on four different types of transmission are: W. S. Worley, The Gates Rubber Co., on V-belts; R. W. Dormer, L. H. Gilmer Co., on flat belts; E. M. Rhodes, Baldwin-Duckworth Division of Chain Belt Co., on roller chain, and C. R. Weiss, Evart Plant, Link-Belt Co., on detachable steel link chain.

Farm Structures and Rural Electric Joint Program. The program will deal exclusively with grain and corn drying and will feature the following papers: Control of fire hazards in grain and corn drying equipment by L. G. Keeney, Farmers' Mutual Reinsurance Assn.; types and performance of grain driers by W. V. Hukill, U. S. Department of Agriculture; adapting corn cribs to grain drying by L. E. Holman, U. S. Department of Agriculture, and rates of drying and moisture distribution within corn cribs by H. J. Barre, Purdue University.

Soil and Water Program. One paper on runoff control and moisture conservation by R. B. Hickok, U. S. Soil Conservation Service, followed by a panel discussion on runoff and conservation practices. The speakers' panel will include L. L. Harrold and C. L. Parrish, U. S. Soil Conservation Service; A. W. Zingg, Missouri Department of Resources and Development; Neal Minshall and R. W. Baird, U. S. Soil Conservation Service, and O. R. Zeasman, University of Wisconsin.

AFTERNOON, TUESDAY, DECEMBER 16

Power and Machiney Program. The program will be devoted mainly to a symposium on the topic "Direct Engine-Driven Power Take-Off". The following speakers will participate: F. N. G. Kranick, farm machinery consultant; A. W. Lavers, Lavers Engineering Co.; L. A. Gilmer, The Oliver Corp.; D. W. Innes, Innes Co.; and Elmer McCormick, John Deere Tractor Co. This will be followed by a discussion of the subject: "The Standard Power Take-Off Speed — Is It Good or Bad?" The discussion will be spearheded by K. W. Anderson, Deere & Co.; C. A. Hubert, International Harvester Co.; Robert Worrell, Allis-Chalmers Mfg. Co., E. W. Tanquary, International Harvester Co., and Martin Ronning, Minneapolis-Moline Power Implement Co.

Farm Structures and Rural Electric (Joint) Program. This will be a continuation of the forenoon program, opening with two papers, one on seed grain drying with calcium chloride by J. W. Simons, agricultural engineering divisions, USDA, and the other on a new instrument for determining temperature gradient in hay by John B. Dobie, California C.R.E.A. The remainder of the session will be devoted to a symposium of brief reports on 1947 results of barn hay drying research, from the following research workers: H. D. Bruhn, University of Wisconsin; Ralph I. Lipper, Kansas State College; C. W. Terry, Cornell University; W. H. Sheldon, Michigan State College, Roy B. Davis, Jr., U. S. Department of Agriculture; G. J. Burkhardt, University of Maryland; A. W. Cooper, Purdue University; Chas. E. Ball, Iowa State College; A. T. Hendrix, Tennessee Valley Authority; A. W. Clyde, Pennsylvania State College.

Soil and Water Program. The following four papers will be presented: Terrace design based on hydrologic data by D. D. Smith, U. S. Soil Conservation Service; increase in resistance to raindrop impact following disturbance of soil by Russell Woodburn, U. S. Soil Conservation Service; results of low-cost concrete flumes by C. A Kinsaid, Portland Cement Assn., and the use of level terraces in Iowa by R. A. Norton, agricultural engineer, U. S. Department of Agriculture.

EVENING, TUESDAY, DECEMBER 16

Barn Hay Curing Round Table. This round table is being sponsored by the A.S.A.E. Committee on Hay Harvesting and Storage, and will be devoted largely to a discussion of the reports on 1947 results of barn hay drying research presented at the preceding afternoon session. The round table is intended to be primarily of interest to research engineers giving special attention to problems of barn hay drying, but the session will be open to all persons interested.

FORENOON, WEDNESDAY, DECEMBER 17

Power and Machinery Program. The program is to be a symposium on the subject: "Should It be Self-Propelled?" (meaning any farm machine that may be equipped for self-propulsion). The principal speakers will be Thos. Carroll, Massey-Harris Co., Ltd., and E. L. Barger, Iowa State College. Prepared discussions on the subject will be presented by S. C. Heth, J. I. Case Co.; C. J. Scranton, Allis-Chalmers Mfg. Co., and D. C. Heitshu, John Deere Harvester Works.

Farm Structures Program. Program consists of four papers as follows: Some new ideas for designing hog farrowing facilities to promote sanitation by H. G. Zavoral, University of Minnesota; cooperative development of a standard milkhouse plant for Michigan by J. S. Boyd, Michigan State College; improved design for grain bin floors by G. L. Nelson, Oklahoma A. & M. College, and arrangement of dairy and beef cattle barns for labor efficiency in feeding by K. H. Hinchcliff, University of Illinois, and Thayer Cleaver, U. S. Department of Agriculture.

(Continued on page 524)

A.S.A.E. Meetings Calendar

November 14 — WASHINGTON (D. C.) SECTION, Room 6962, South Bldg., USDA (11:50 a.m.)

November 15 — TENNESSEE SECTION, New Ag. Eng. Bldg., Knoxville.

November 15 — MICHIGAN AREA SECTION, Hotel Hayes, Jackson, Mich.

December 15 to 17 — WINTER MEETING, Stevens Hotel, Chicago.

June 21 to 24 — ANNUAL MEETING, Multnomah Hotel, Portland, Oregon.

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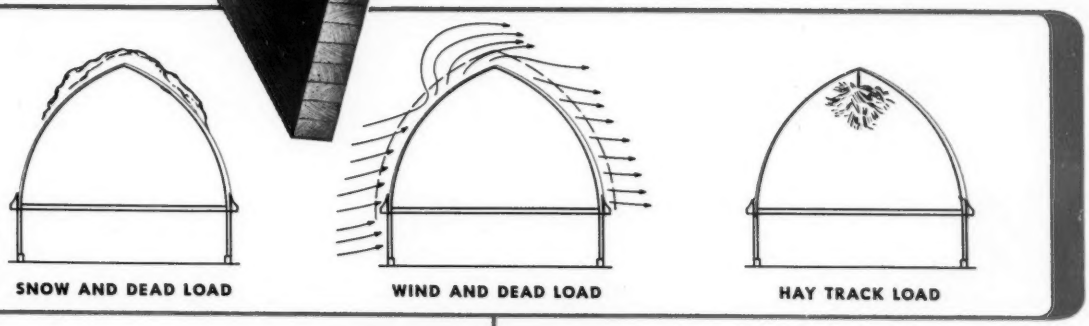
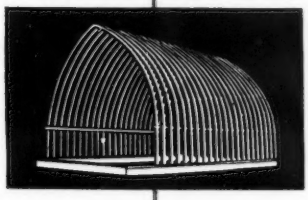


SNOW AND DEAD LOAD

WIND AND DEAD LOAD

HAY TRACK LOAD



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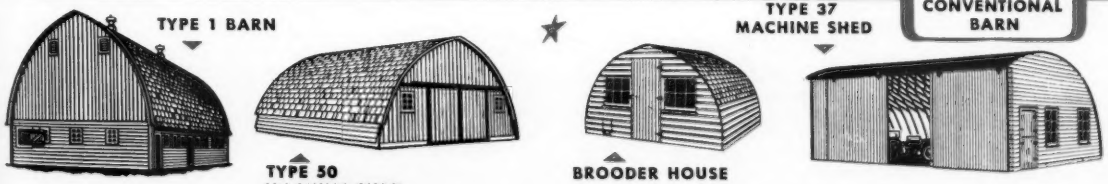

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NEWS SECTION

(Continued from page 522)

AFTERNOON, WEDNESDAY, DECEMBER 17

Power and Machinery Program. This program will be devoted to engineering presentations on some of the newer and more outstanding farm machines, to include the following: The No. 24 International Harvester corn picker by A. J. Keller, International Harvester Co,; the whirlwind (experimental) ditcher by E. V. Collins, Iowa Agricultural Experiment Station.

Farm Structures Program. Following a survey report on 160 dairy barns in New Jersey by H. E. Besley and a report on the results of comparative studies of insulated and non-insulated dairy barns by W. C. Krueger both of Rutgers University. The remainder of the session will be devoted to four papers as follows: How to use structural clay tile in farm construction by John M. Anderson, Structural Clay Products Institute; the coordination of functional requirements for farm buildings by Geo. A. Rietz, Better Farm Buildings Association; how to use asbestos sheets in farm building construction by A. W. Bergman, Cement Asbestos Products Assn., and how to increase the life of asphalt roofing on farm buildings by J. L. Strahan, Asphalt Roofing Industry Bureau.

Non-members as well as members of the A.S.A.E. are welcome to attend any and all sessions of the meeting. Printed copies of the program for the meeting will be mailed to all members of A.S.A.E., and non-members may obtain copies as well as other information regarding the meeting from Society headquarters at St. Joseph, Michigan.

Fertilizer Application Program Announced

THE National Joint Committee on Fertilizer Application has scheduled a full day's program for its meeting December 15, in conjunction with the winter meeting of the American Society of Agricultural Enginers, December 15-17 at the Stevens Hotel in Chicago.

"Soil Fertility and Plant Breeding in Relation to Fertilizer Application" is to be the opening general subject. Presentations are scheduled on "the Plant Breeding Phase" by F. H. Hull, "The Soils Phase" by Firman E. Bear, "The Fertilizer Phase" by H. B. Siems, and "The Farm Equipment Phase" by W. A. Roberts.

"Radioactive Applications to Agriculture," the newest influence in the fertilizer field, are to be introduced the same morning, by Nathan H. Woodruff, chief, technical branch, isotopes division, Oak Ridge Operations, U. S. Atomic Energy Commission, by Vincent Sauchelli representing a chemical manufacturer, and by W. L. Nelson, of the North Carolina Agricultural Experiment Station.

Attention during the afternoon will be centered on "Special Fertilizer Placement Problems." Specific problems to be covered include "Soil Compaction" by G. N. Hoffer, "Liquid Fertilizers" by W. B. Andrews, "Subsoil Treatment" by N. J. Volk, and "Irrigation Conditions" by Frank G. Steward.

A cordial invitation is extended to A.S.A.E. members by the National Joint Committee to attend the sessions of its meeting.

RESEARCH NOTES

(Continued from page 518)

On the following day the visitors heard R. M. Salter, chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, highlight the Bureau's work in several broad fields of investigation. Progress in chemical weed control and the various uses of 2,4-D were described by L. W. Kephart and J. W. Mitchell of the division of cereal crops and diseases. Dr. Kephart said that there is a large field in the use of oils for weed control. The job is done by aromatics in the oil, and it is the lower classes of oils that carry them.

Dr. Gotthold Steiner told something of the Bureau's work on nematodes, showing slides, and Dr. J. C. Dunegan reported recent results in plant pathology research. He expressed the hope that organic chemists and the oil industry would develop new compounds to handle many adverse conditions. Following a discussion of fruit storage problems by Dr. D. F. Fisher, the group inspected several refrigerated rooms at the Plant Industry Station where various fruits and vegetables were stored under different temperatures and humidities. Studies on reactions of plants to light were reported by Dr. H. A. Borthwick, and members of the party saw the spectrograph in operation on plants.

Back at the Research Center farm for the afternoon session, the conference group visited the poultry laboratories and the dairy buildings, hearing explanations of work in progress. Dr. L. A. Moore spoke in some detail about investigations on the feeding of thyroprotein to increase milk production. Miss Lenore Sater of the Bureau of Human Nutrition and Home Economics demonstrated home freezer research and an experimental kitchen, and Dr. F. C. Bishopp of the Bureau of Entomology and Plant Quarantine talked briefly on insecticides and control research. The concluding round-table discussion was led by George Krieger, chairman, Agricultural Committee, American Petroleum Institute.

Soil Conservation Meeting in December

OMAHA, Nebraska, will be host to the second annual meeting of Soil Conservation Society of America, December 4 and 5.

"Soil Conservation and a Permanent Agriculture," by the Hon. Charles F. Braunan, Assistant Secretary of Agriculture, is scheduled to keynote the opening of the meeting. It is to be followed in the afternoon by a symposium, entitled "An Appraisal of Research Needs in Soil and Water Conservation." A.S.A.E. members on the panel are Arnold P. Yerkes on "Industrial Research," and Geo. D. Clyde on "Water Management and Disposal." Other subjects and speakers on this panel are "Soil Permeability" by G. W. Musgrave; "Effect of Tillage on Physical Structure" by G. M. Browning; "Economics of Conservation" by M. M. Kelso, and "Forest Influences" by C. F. Korstain.

Another symposium, on "Relation of Soils to Nutrition and Health," is under development for the latter part of the afternoon.

E. H. Taylor, associate editor, "Country Gentleman," is to address the annual dinner meeting on "Our Changing Land Policy."

Round tables are scheduled to occupy Friday morning, December 5. Subjects include "Water Management in Relation to Runoff and Siltation," "Appraisal of Education Needs in Soil Conservation," and "Soil Conservation — What Progress has been Made? What Must be Done?"

A luncheon and business session will close the meeting, which will be held at the Fontenelle Hotel in Omaha.

Hurlbut New A-E Head at Nebraska

ANNOUNCEMENT was made recently of the appointment of Lloyd W. Hurlbut as the new chairman of the agricultural engineering department at the University of Nebraska, succeeding E. E. Brackett, who has retired from the post.

Mr. Hurlbut is an agricultural engineering graduate of Kansas State College, and has a master's degree from the University of Nebraska. Following nine years of service on the agricultural engineering staff of the University of Nebraska, he served two and one-half years with the U. S. Navy during World War II, attaining the rank of lieutenant. For a period of six years, 1936-1942, he served as a member of Nebraska Tractor Testing Board. More recently he has been assistant professor of agricultural engineering and associate in the agricultural experiment station at Purdue University.

Kohler Heads Pacific Northwest Section

THE Pacific Northwest Section of the American Society of Agricultural Engineers, during its first annual meeting at the Davenport Hotel, Spokane, Wash., October 23 and 24, elected Karl O. Kohler, Jr., regional engineer, Soil Conservation Service, USDA, as chairman of the Section for the ensuing year. The following other officers were also elected: First vice-chairman, J. R. W. Young, head, agricultural engineering department, University of British Columbia; second vice-chairman, J. B. Rodgers, head, agricultural engineering department, Oregon State College, Corvallis; third vice-chairman, Curtis V. Edwards, president, Edwards Equipment Co., and secretary-treasurer, A. G. Mayer, manager, farm development, The Washington Water Power Co.

The registered attendance at the meeting was considerably in excess of 100 and included a large number of agricultural engineering students enrolled in agricultural engineering courses at the State College of Washington, University of Idaho, Oregon State College, and the University of British Columbia. An excellent program was presented. During the business meeting of the Section, there was considerable discussion of the arrangements for the next annual meeting of the Society to be held at Portland, Ore., in June of next year, to which the Pacific Northwest Section will play host. The group is taking on the responsibility for this event with a great deal of enthusiasm.

Next Michigan Section Meeting

THE Hayes Hotel at Jackson, Michigan, Saturday, November 15, is announced as the place and time for the next meeting of the Michigan Area Section of the American Society of Agricultural Engineers. Program features are to be announced later, when all arrangements have been completed.

New Georgia A-E Staff Appointments

THE agricultural engineering department of the University of Georgia announces the appointment of Carlisle Cobb, Jr., as instructor in soil and water conservation and utilization to replace T. V. Wilson, resigned. C. E. Rice is the new assistant professor of power and machinery, replacing S. M. Henderson, who is on a year's leave of absence. R. D. Dixon is the new research assistant in the division of agricultural industries and services. J. M. Stanley has been appointed research assistant professor and is a cooperative employee with the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering in rural housing, farm structures, and utilities, and similar arrangement is effected in the appointment of L. L. Smith as research associate and junior agricultural engineer. A. P. Barnett has been appointed research associate and agricultural engineer in cooperation with the USDA Soil Conservation Service, in the division of soil conservation and utilization.

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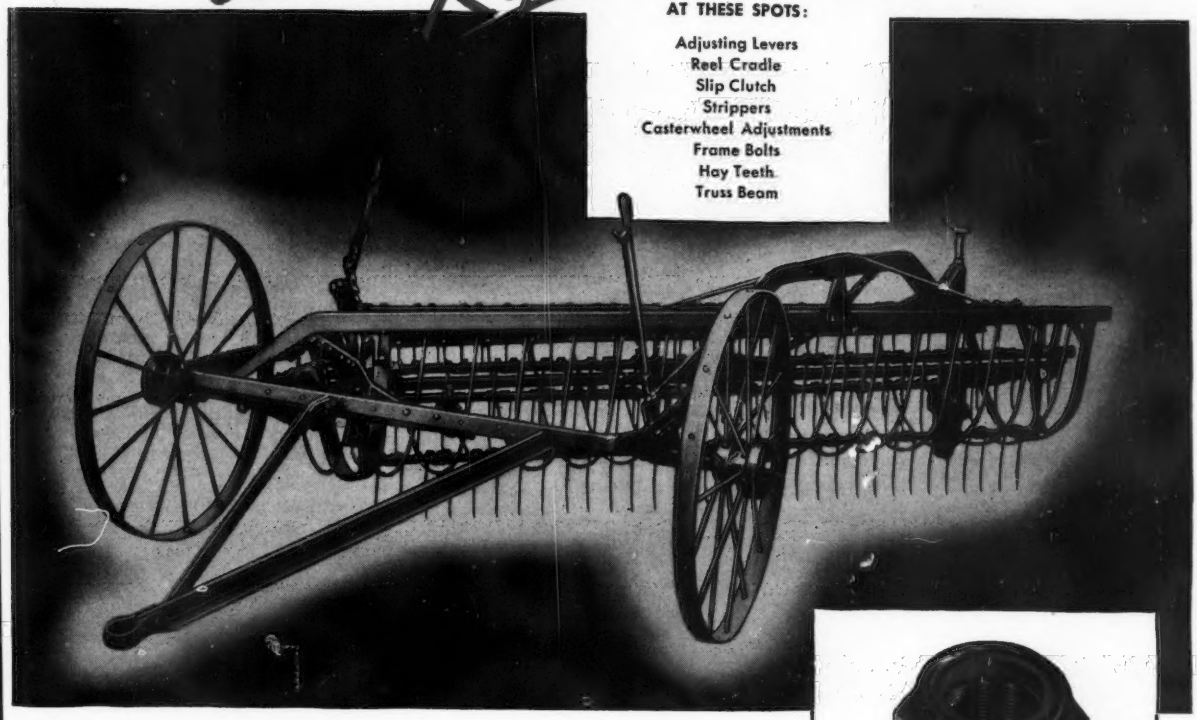

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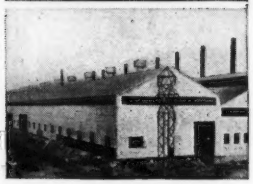

34 YEARS . . . Erected in 1913, and covered with heavy gauge galvanized sheets, this Tennessee concentrating plant of the A/Z Company, pictured at left, is still in excellent condition after more than three decades of service. Painted with Gray Metallic Zinc Paint in 1932.

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Ag Engineers Judge Welding Competition

E. W. LEHMANN, G. W. McCuen, and I. G. Morrison served during the past year as agricultural engineering representatives on the Jury of Awards of the James F. Lincoln Arc Welding Foundation. The Jury selected winners, recently announced, in a $200,000 "Design-for-progress" competition. There were four awards in the farm machinery classification, and some winners in other classifications whose contributions covered the use of welding in the manufacture and maintenance of farm equipment.

Tennessee Reports Additions

RECENT additions to the facilities of the agricultural engineering department at the University of Tennessee, including a new 40x100-foot farm machinery laboratory and a 20x30-foot addition to another laboratory, are reported by M. A. Sharp, head of the agricultural engineering department.

Personals of A.S.A.E. Members

C. Howard Bingham, a recent graduate of Ohio State University, is now a member of the agricultural engineering extension staff of Pennsylvania State College.

M. V. Engelbach, manager of field engineering of the Ruberoid Company, has been appointed the representative of the Asbestos Cement Products Association to the American Standards Association.

Norman A. Evans recently completed his work for a master's degree at Utah State Agricultural College and has joined the agricultural engineering staff of North Dakota Agricultural College. He will teach courses in irrigation, soil conservation, and land reclamation.

Dan N. Harrell has resigned as extension agricultural engineer with the Georgia Agricultural Extension Service to accept a position as district supervisor of the Florida Ford Tractor Co., Jacksonville, Fla.

Paul W. Jenicek is a structural design engineer for the Stone Webster Engineering Corporation and is presently engaged on a plant expansion project for the Ethyl Corporation at Baton Rouge, Louisiana.

Wm. Kalbfleisch is on leave as agricultural engineer, Experimental Farm Service, Department of Agriculture of Canada, and is serving as machinery specialist of the Food and Agriculture Organization of the United Nations. He has been spending some time in England and more recently in Austria.

Henry Karrer has resigned as field office superintendent of the USDI Bureau of Reclamation at Bakers Field, Calif., to enter the employ of the Fresno (Calif.) Irrigation District as their engineer-manager.

William J. Ridout has resigned as extension agricultural engineer of the South Carolina Extension Service, to accept appointment as rural service manager of the Edison Electric Institute, 420 Lexington Ave., New York, succeeding Roy W. Godley. In his new position Mr. Ridout will supervise farm electrification activities of E.E.I. and will assist the various committees of the Institute's farm section. Mr. Ridout is an agricultural engineering graduate of Virginia Polytechnic Institute.

Vernon Selde has recently accepted appointment as a P 1 engineeer with the Colville Indian Reservation at Nespelem, Wash. He will be engaged in the development of irrigation systems, springs, and soil and moisture conservation structures.

Necrology

GERALD GERALDSON, chief engineer, Rockford Plant, J. I. Case Co., and a member of A.S.A.E. since 1943, passed on September 21 after a brief illness. He was born November 12, 1884, in Norway. His connection with agricultural engineering started in 1916, with employment in the J. I. Case Plow Works in the capacity of designing engineer. in 1925 he left this position for similar work with the S. L. Allen Co. He returned to the Case organization in 1927, and in 1937 was made chief engineer of its Rockford, Illinois, plant. In addition to his capacities as an engineer, he was an ordained minister and an active leader in the Bethesda Covenant Church in Rockford.

Mr. Geraldson is survived by his widow, two daughters, three sons, five sisters and five grandchildren.

ALBERT O. KAY, engineer appraiser for the Federal Land Bank of Columbia, S. C., and a member of A.S.A.E. since 1925, passed away September 26.

Born in Philadelphia, Pa., April 1, 1888, he graduated from Northeast Manual Training High School in 1906, and started work as chairman for the Philadelphia Bureau of Surveys. Through experience and additional study at Drexel Institute and Wagner Free Institute he advanced to rodman, transitman, and draftsman. In 1918 he resigned his position in Philadelphia to become junior drainage engineer in the Bureau of Public Roads, U.S. Department of Agriculture. He later advanced to associate drainage engineer, and in 1921 was placed in charge of the Florida drainage and soil moisture work of the Division of Agricultural Engineering. After a number of years he transferred to engineer-appraisal work for the Federal Land Banks.

He is survived by his widow, Reha V. Kay.

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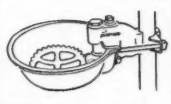

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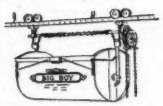

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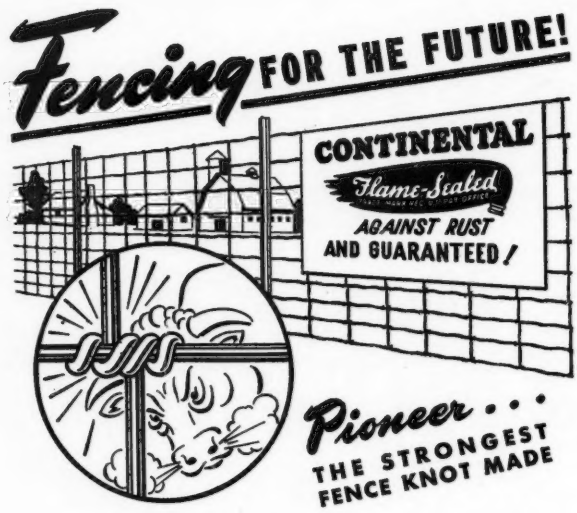

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Russell H. Benedict, instructor in agricultural engineering, Iowa State College, Ames, Iowa. (Mail) 713 Carroll

Allison W. Blanshine, design engineer, The Oliver Corp., Battle Creek, Mich. (Mail) R. R. No. 1, Box 83

L. L. Boyd, research fellow in agricultural engineering, Iowa State College, Ames, Iowa

Delbert M. Byg, instructor in agricultural engineering, Ohio State University, Columbus, Ohio

Cleveland L. Campbell, agricultural marketing service, American Rolling Mill Co., Middletown, Ohio

Thomas G. Campbell, Jr., instructor in agricultural engineering, California Polytechnic College, San Luis Obispo, Calif. (Mail) Box 304

Paul D. Colbenson, instructor in agricultural engineering, University of Tennessee, Knoxville, Tenn.

Harry H. Converse, Converse Farm Service Co. (farm machinery dealer), Eskridge, Kan.

Warren H. Corbet, junior engineer, John Deere Tractor Co. (Mail) 432 Home Park Blvd., Waterloo, Iowa

Lester B. Eckles, electrical engineer, Brown Engineering Co., 326 K. P. Bldg., Des Moines, Iowa

Battle B. Ewing, assistant agricultural engineer, Mississippi Delta Branch Experiment Station, Stoneville, Miss.

Gustave E. Fairbanks, assistant professor of agricultural engineering, Kansas State College, Manhattan, Kan.

Maximo A. Fernandez, dairying, Hacienda La Giralda, Alajuela, Costa Rica. (Mail) Box 1404. Clemson, S. C.

Owen A. Fordham, agricultural engineer, Public Service Co. of Northern Illinois, Box 278, Glencoe, Ill.

Warren Gibson, agricultural engineer, Ewa Plantation Co., Ewa, Oahu, Hawaii.

John M. Goodman, agricultural engineer, South Carolina Power Co. (Mail) 141 Meeting St., Charleston, S. C.

Wilfred E. Gould, agricultural engineer, Illinois Northern Utilities Co. (Mail) 107 Prospect St., Morrison, Ill.

Wesley W. Gunkel, research fellow in agricultural engineering, Iowa State College, Ames, Iowa.

W. N. Hart, graduate fellow in agricultural engineering, Michigan State College, East Lansing, Mich. (Mail) 3328 E. Michigan Ave.

Clarence J. Hauser, Oscar Mayer Co., Madison, Wis. (Mail) 217 N. Orchard

Horace M. Haws, Jr., instructor in agricultural engineering, Oklahoma A. & M. College, Stillwater, Okla.

Richard W. Henzel, president, Tulana Farms, Worden, Ore.

James M. Jackson, graduate assistant in agricultural engineering, Alabama Polytechnic Institute, Auburn, Ala.

Donald E. Jewell, instructor in agricultural engineering, University of Wyoming, Laramie, Wyo. (Mail) 117 Hoyt Street

William M. Johnson, administrative assistant, Quaker Oats Co., 141 W. Jackson Blvd., Chicago 4, Ill.

E. D. Kaser, president and general manager, Durabilt Mfg. Co., Aurora, Ill.

David R. Long, instructor in agricultural engineering, Oregon State College, Corvallis, Ore.

E. B. Martin, extension agricultural engineering, Alberta Department of Agriculture, Legislative Buildings, Edmonton, Alta., Canada

James B. Moore, Jr., vice-president and secretary-treasurer, Peirson-Moore Co., Inc., 740 National Ave., Lexington, Ky.

Ronald C. Murray, chief engineer, Ottawa Steel Products Co., Ottawa, Kan.

Wilfrid J. Nolan, agricultural advisory engineer, Shell-Mex and B. P. Ltd., Shell-Mex House, Strand, W C 2, London, England

John T. Oakley, assistant blockman, International Harvester Co. (Mail) 1105 14th Place, South Milwaukee, Wis.

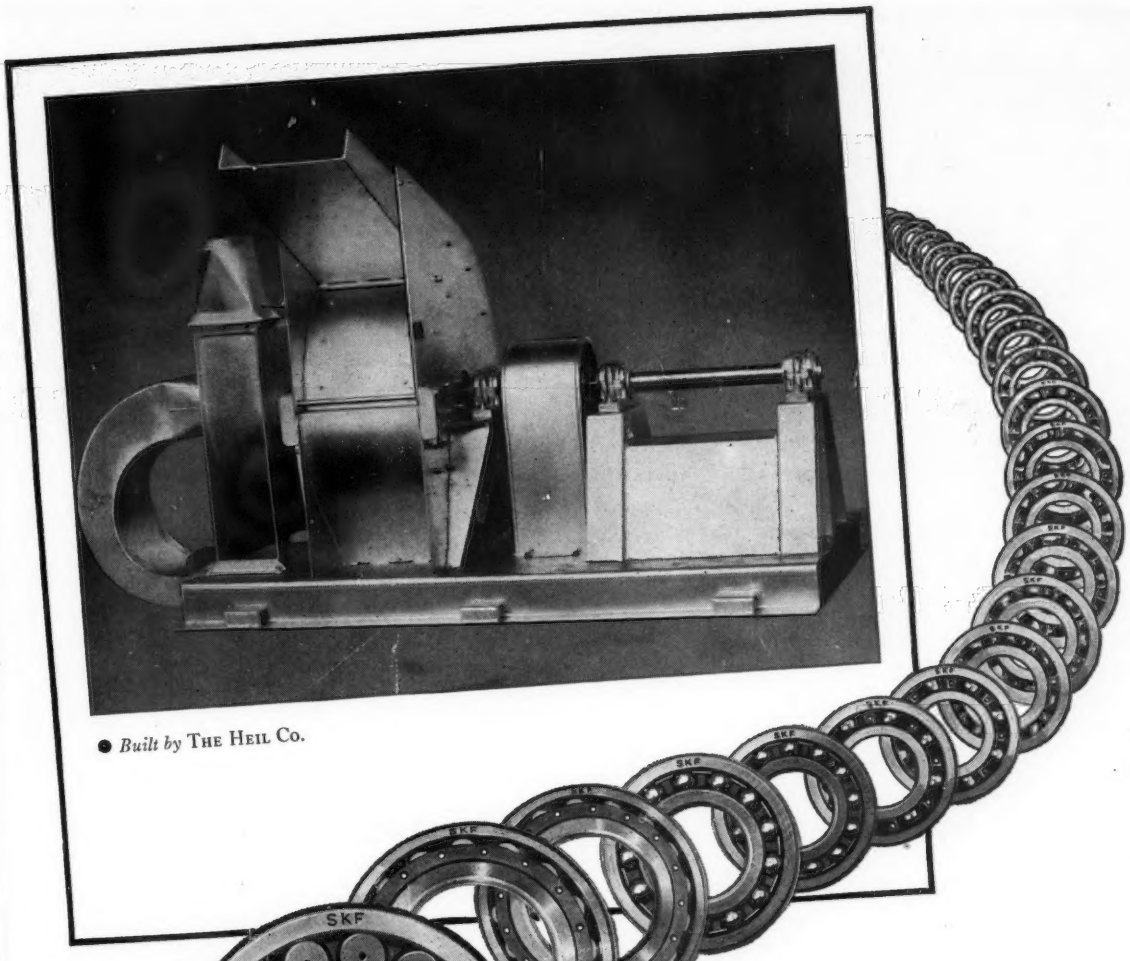
Warren A. Petersen, chief engineer, Smalley Mfg. Co., Manitowoc, Wis. (Mail) 1106 N. 11th St.

Aubrey M. Pettis, extension farm electrification specialist, Extension Service, University of Florida, Gainesville, Fla. (Mail) Box 2109, University Station.

A. M. Powell, Jr., 1550 S. Lumpkin St., Athens, Ga.

Edward C. Procter, engineering design draftsman, New Holland Machine Co., New Holland, Pa. (Mail) 29 Custer Ave.

Richard E. Reeves, sales engineer, Decatur Pump Co. (Mail) Weldon, Ill.



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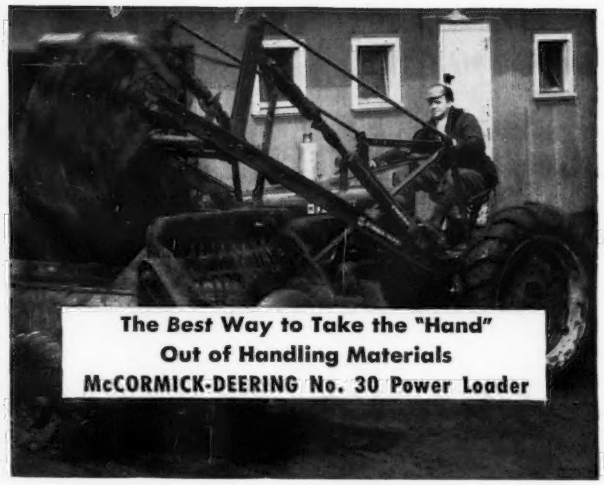

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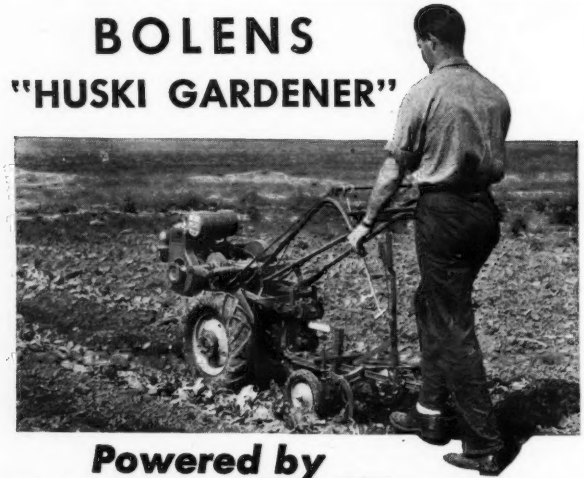

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Applicants for Membership

(Continued from page 528)

Rodney P. Ryker, supervisor of hydraulics, Washington Department of Conservation and Development, Olympia, Wash.

Ernest N. Scarborough, graduate student in agricultural engineering, Iowa State College, Ames, Iowa

Myron B. Shoff, president, Peoria Equipment Co., and proprietor, Sho-Off Orchards Products Co., 107 N. Washington St., Peoria, Ill.

Mahesh P. Sinha, agricultural engineer, District Agricultural Office, Bhagalpur, Bihar, India. (Mail) Bliss Cottage, Masak Chak

Eugene T. Smith, production manager, Hagies Hybrid, Inc., Clarion, Iowa

Lloyd L. Smith, agricultural engineer, U. S. Department of Agriculture. (Mail) 561 University Drive, Athens, Ga.

Theodor W. Suberkropp, field engineer and serviceman, Krause Plow Corp., Hutchinson, Kans. (Mail) 403 East 11th St.

Albert J. Swearingen, sales promotion, The Oliver Corp. (Mail) 29 Hotel St., Memphis, Tenn.

Alfred M. Thym, associate in agricultural engineering, University of California, Davis, Calif.

James Turnbull, civil engineer, Division Drainage and Water Control, Soil Conservation Service, USDA. (Mail) Citrus Experiment Station, Lake Alfred, Fla.

Ward W. Wallace, student trainee, J. I. Case Co. (Mail) 313 South Duluth, Sioux Falls, S. D.

Donald D. Winslow, supervisor, methods engineering, De Laval Separator Co., Poughkeepsie, N. Y. (Mail) Van Wagner Road, R. R. No. 1.

William H. Yaw, research assistant, agricultural engineer, Purdue University, Lafayette, Ind.

TRANSFER OF GRADE

Milton V. Beckham, superintendent for Harry Brown, general contractor, Milledgeville, Ga. (Junior Member to Member)

Craig W. Cannon, foreman in charge of tractor proving grounds, Tractor Div., Allis-Chalmers Mfg. Co. (Mail) Box 518-A, R. R. 4, Waukesha, Wis. (Junior Member to Member)

William F. Martin, agricultural engineer, Virginia Electric Cooperative, Bowling Green, Va. (Junior Member to Member)

Francis M. Roberts, agricultural engineer, Soil Conservation Service, USDA. (Mail) Afton, Wyo. (Junior Member to Member)

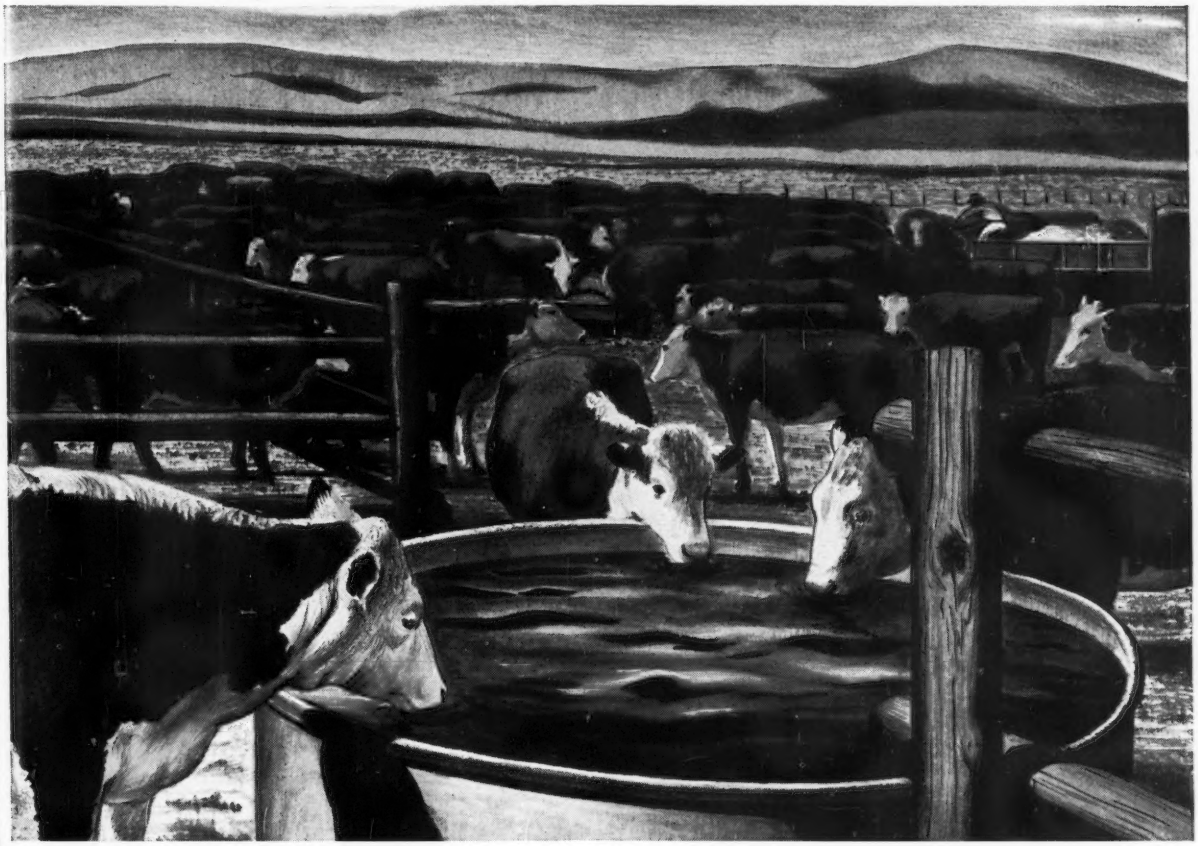
New Literature

Electric Beak Cauterization by J. Lyon. Paper, 12 pages, 8½ x 11 inches. Illustrated. Lyon Rural Electric Company, San Diego, California. Copies available without charge for educational work. A brief story of the history and development of "debeaking" equipment, with particular emphasis on the products of the Lyon Rural Electric Co.

New Federal and State Bulletins

Farm Sewage Disposal by E. A. Olson, Nebraska (Lincoln) Agricultural Extension Service, Circular 703 (June 1947).

Septic Tanks for Dwellings by Earl G. Welch and James B. Kelley, Circular 431, University of Kentucky, Lexington.



This special zinc coating fights farm rust longer

Farmers want stock tanks, hog feeders, poultry waterers and other equipment that give longer protection against rust. That's exactly what they get when the manufacturer uses ARMCO ZINCGRIP Steel. Atmospheric field tests on this special-purpose steel show that ZINCGRIP offers 15 to 45 per cent greater corrosion resistance than regular galvanized steel.

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TURN IN YOUR SCRAP NOW—*Help make more steel*

Scrap piles in most steel mills are critically low. Unless this shortage is relieved, everybody must wait longer for steel. Perhaps you can aid by checking unusable tools, machines and obsolete equipment. Help collect all the iron and steel scrap you can find and speed it through regular channels to the mills. Remember *—more scrap means more steel, sooner.*

ARMCO

THE AMERICAN ROLLING MILL COMPANY

- SPECIAL-PURPOSE SHEET STEELS
- STAINLESS STEEL SHEETS, STRIP, BARS AND WIRE

WE CALL IT

"Wheeled"

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Mobile Equipment is Only as Strong as the Wheels Upon Which it is Mounted.

The modern metal wheel — originated by French & Hecht — launched the progress which has made America the greatest of all food producers. TODAY, Wheels by French & Hecht are available for every mobile need in agriculture and industry. There is no real limit to the loads, speeds and harshness of service which can be met by soundly engineered wheels. More than a half century of "doing" enables us to design, test, and fabricate the wheels required by the mobile equipment you produce.

Send Your Wheel Problems to Us

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DIVISION

KELSEY-HAYES WHEEL COMPANY

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Protecting Crops, Machinery, Homes

SISALKRAFT Does It

On farms — like any other business — every dollar saved is that much profit. Wind, rain, sleet, snow — exposure of every kind — can do much damage to harvested crops, machinery, buildings. With Sisalkraft much of this loss can be avoided.

Sisalkraft is ideal for temporary silos — emergency storage of grain — covering hay stacks — protecting machinery — curing concrete — lining poultry houses — protecting the home — plus many other uses. Costs little. Tough, tear-resistant, and waterproof. Can be used again and again.

Sisalkraft is sold through lumber dealers everywhere. Write for folders on Sisalkraft's many farm uses.

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: 1946 JUNE — O-506. SEPTEMBER — O-516. NOVEMBER—O-523. DECEMBER—O-526. 1947 MARCH—O-543. APRIL—O-552. MAY—O-564. JUNE—O-567, 569, 571. JULY—O-574. AUGUST—O-576, 577, 579. SEPTEMBER—O-581, 582, 584. OCTOBER—O-585, 586, 587, 588, 589, 590, 591.

POSITIONS WANTED: 1946 FEBRUARY—W-207. MAY—W-309. JUNE—W-320. SEPTEMBER—W-337. 1947 FEBRUARY—W-373. APRIL—W-387, 389. MAY—W-395, 398, 101, 103. JUNE—W-105, 106. JULY—W-112. AUGUST—W-114, 118. SEPTEMBER—W-119, 120. OCTOBER—W-124.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER (Instructor) for teaching farm machinery and related subjects in a state school in the East. BS deg in agricultural engineering. Farm background. Previous teaching or experience in the farm machinery field required. Annual basis with one month vacation. Starting salary $4,454 with yearly increments of $300 to $5,472. O-592

AGRICULTURAL ENGINEER for teaching and research in farm buildings in a southern land grant university. BS deg in agricultural engineering or equivalent. Several years in farm structures field considered in lieu of MS deg. Veterans will be given preference. Salary $3,600, or higher. O-593

AGRICULTURAL ENGINEER for research in farm buildings, with emphasis on farm by-product building materials in southern agricultural experiment station. BS or MS deg in agricultural engineering or equivalent, and about 5 years experience in farm structures field. Sound foundation in chemistry. Twelve-month basis, with 30 days vacation. Age 25-35. Salary open. O-594

AGRICULTURAL ENGINEER for research in farm machinery, with emphasis on grass and weed control, particularly in cotton production, in southern agricultural experiment station. BS or MS deg in agricultural engineering or equivalent, with sound foundation in agronomy. Some experience in this or closely related fields desirable. Must know cotton. Twelve-month basis, with 30 days vacation. Age 25 - 35. Salary open. O-595

AGRICULTURAL ENGINEER (Instructor) for teaching and some research in soil and water conservation, in an eastern land grant university. BSAE, farm background, and preferably some experience in soil conservation. Usual personal qualifications for college teaching. Twelve-month basis. Salary $3,000. O-596

NEW POSITIONS WANTED

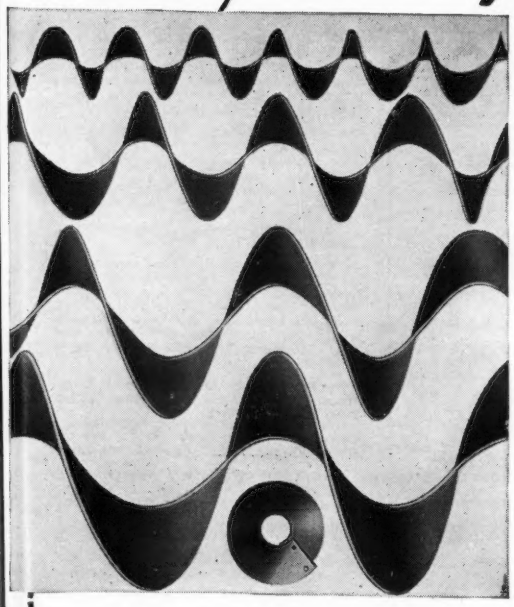
AGRICULTURAL ENGINEER desires development or research in machinery or farm structures in high, dry climate needed for health of family. Also interested in part time study for advanced degree. BS deg in agriculture, with major in agricultural engineering, 1939, Michigan State College. Farming from 1939 to present, and taught high school vocational agriculture two years, 1942-44, in addition. No physical defects. Available in December. Married. Age 33. Salary open. W-125

AGRICULTURAL ENGINEER desires public service project work or teaching in land grant college in soil and water field. BS deg in agricultural engineering, 1947, Kansas State College. Experience since graduation in surveying, farm terrace layout, and as junior civil engineer for Triborough Bridge and Tunnel Authority (NY). Army experience as noncommissioned officer in infantry and ordnance, with promotion to Master Sergeant. No physical defects. Available on short notice. Married. Age 24. Salary $2,600 minimum. W-126

AGRICULTURAL ENGINEER desires sales, maintenance or development work in farm machinery field, with commercial organization. BSAE, 1943, Pennsylvania State College, MSA, Cornell University, expected in February 1948. One summer as research assistant, New York State Farm Electrification Council. District agricultural engineer, 8 months, Extension Service, New York. Summers of 15 years in truck farming, and of 3 years in dairy farming. War service 3 years in U. S. Naval Reserve, including 2 years overseas with Seabees, in rank of Lt. (jg). No physical defects. Available on or about March 1, 1948. Married. Age 25. Salary $3,000. W-127

AGRICULTURAL ENGINEER desires research, development, or service work in farm power and machinery field. BSAE, University of Nebraska, 1943. Additional engineering study in Case Institute of Technology and John Huntington Polytechnic Institute. Experience in farm equipment and aircraft power plant engineering. No physical defects. Available on 3 weeks notice. Married. Age 28. Salary open. W-128

Screw Conveyor from LINK-BELT Serves Many Purposes!



Link-Belt Company originated and is the largest producer of continuous rolled "Helicoid" conveyor. Standard sizes range from 2½" to 18" outside diameter. For conveying, elevating, mixing, blending, of loose, granular material use "Helicoid" conveyor and Sectional Flight Conveyor by LINK-BELT.

Increased use of screw conveyor on modern farm equipment is a natural development, as its special advantages become recognized. Application of screw conveyor to manure spreaders of recent design is an example of the resourcefulness of engineers, and illustrates the adaptability of this type of conveyor to various purposes, besides conveying bulk material such as grain, in the usual manner.

Through unmatched experience and production facilities, Link-Belt Company is especially well equipped to supply screw conveyor and flighting, either continuous rolled "Helicoid" or sectional, to the agricultural implement industry. We welcome inquiries and will gladly cooperate with your designers in making effective use of this efficient form of conveyor.

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AGRICULTURAL ENGINEERING

Established 1920

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MILLIONTH FARMALL*

FARMALL M—biggest in the line. For large, diversified farms.

Just FARMALL Tractors alone—a *million* of them!

International Harvester has built many hundreds of thousands of *other* tractors, too. We're not counting them in.

Think what a *million* means. That's 20,833 Farmall Tractors for every state in the union (average). That's 325 Farmalls for every one of the 3,072 *counties* in the United States. And the vast majority of the 999,999 Farmalls that followed the *Original* All Purpose Farmall Tractor in 1923—nearly 9 out of every 10 of them—*are on the job today.*

In every row-crop farming area of the United States the great overwhelming tractor favorite is the FARMALL. Look around you, anywhere. The evidence is on the farms, for every man to see.

Today, with the advent of the Farmall Cub, there are *five* sizes of Farmalls and matched equipment for all—your choice at the store of your International Harvester Dealer. Rely on the FARMALL SYSTEM and the record set by a million Farmall Tractors.

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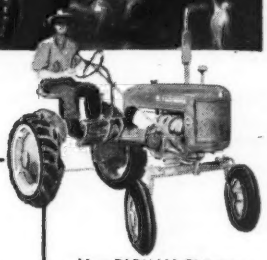
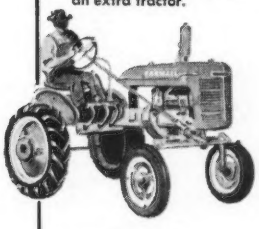
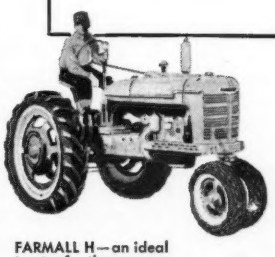
***The Farmall name is an IH trade-mark registered in the U. S. Patent Office. ONLY International Harvester makes Farmall Tractors.**



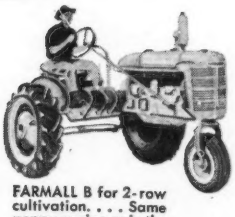
New FARMALL CUB tractor for small farms. Also for large farms that need an extra tractor.



FARMALL A, a 1-row, 1-plow tractor with "Culti-Vision."



FARMALL H—an ideal tractor for the average quarter-section farm.



FARMALL B for 2-row cultivation. . . . Same peppy engine as in the Farmall A.

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TEXACO *Presents Exclusively*-SPECIAL RKO PATHE FARM NEWS MOVIE

WE polled Farm Magazine Editors, Agricultural Engineers and our field men in all 48 states to find new labor-saving, money-saving devices developed on the farm and at the Agricultural Colleges. Also human interest features and accepted new farm practices. Then RKO Pathe sent movie crews to the four corners of the country to film them.

It's a motion picture everyone will enjoy. It's exclusive. It's new. It's entertaining. It's informative. It will be shown exclusively at Texaco Farm Meetings from coast to coast. See your local Texaco Man for time and place. Bring the whole family. The following are a few of the features you'll see in Texaco's new Farm Film, "It's NEWS Because It's NEW"

Mr. David Wheatley of Napa, Calif., has reduced the hazards, the time and much of the hand labor of pruning with this novel self-propelled pruning tower equipped with a "press button" pruner. Shears are operated by compressed air. It is easy to make. See it work in Texaco's new Farm Film.

Clarence Carlson of Marshalltown, Ia., young farmer, and nationally known inventor, demonstrates his new electric corn planter to Don Dobson, his Texaco Man. Several planting units can be installed on crossbar under tractor. They operate on battery current of tractor.

This NEW "easy chair" sweet potato transplanter has proved satisfactory in tests at A. and M. College of Texas. It's a big time saver, eliminates "bend-over" labor in transplanting. See it work, get complete details at Texaco Farm meetings.

The Moore Brothers of Navasota, Texas, take the guess and a lot of the bother and work out of lubrication with this novel farm machinery service station on wheels. They find it pays also to farm with Texaco products.

Every member of the family will enjoy seeing how the Koberles' of Middleton, Wis., make their famous dolls from farm products. Here's a grand pastime for the children. Develops their creative ability.

A FEW COPIES OF FILM AVAILABLE FOR SHOWING AT FARM MEETINGS
Texaco has a few extra copies of this interesting and informative film and will be glad to lend them to Agricultural Teachers, for showing at farm meetings. Write to Sales Promotion Division, The Texas Company, 135 East 42nd Street, New York 17, New York.
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Tune in: TEXACO STAR THEATER presents the TONY MARTIN show featuring Alan Young every Sunday night. METROPOLITAN OPERA broadcasts every Saturday afternoon. See newspaper for time and station.

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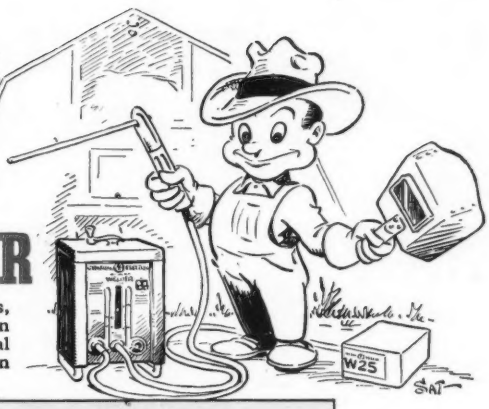
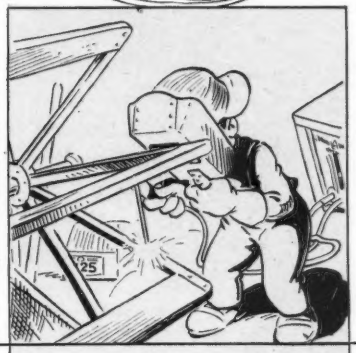
"Farmer" Joe MaGee demonstrates a NEW TOOL for the modern farm... the

FARM WELDER

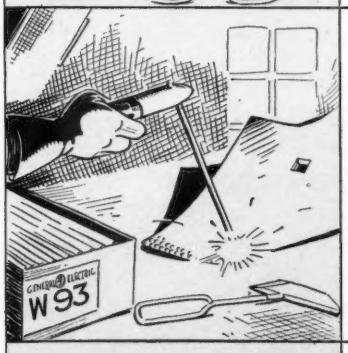


Introducing Joe MaGee—Joe is a little character (fictitious, of course) who has had considerable "experience" in industrial welding. Now he is venturing forth into rural areas to demonstrate what welding can do for the modern farmer, using the new G-E Farm and Home Welder.

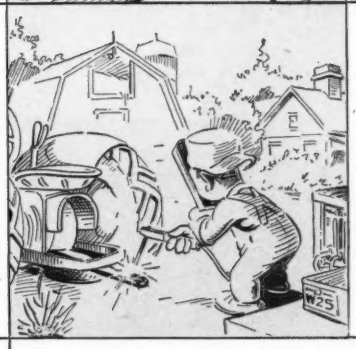
IN GENERAL...
Welding can be an invaluable farm tool and aid—and the G-E Farm Welder has been designed and built *specifically for welding on the farm!*



REPAIRING
With the G-E Farm Welder, repairs can be made quickly, "on the spot" without loss of valuable time. A prompt weld may save an entire crop!



HARD SURFACING
Prolong operating life by resurfacing and rebuilding worn surfaces (plow shares, gears, pinions, etc.).



MODIFYING
It's easy to add touches of your own to make standard farm equipment better suited to your individual needs.

RIGHT ELECTRODES
Using the *right electrode* is important to any good welding job; we recommend these G-E electrodes to handle most of your needs:

For general-purpose welding—W-25

For hard-surfacing—W-93

SEE THE FARM WELDER

at your nearest G-E distributor or dealer (if he doesn't have any yet, he will shortly). You'll like the compact design, and the price—as low as $152. Or, write for descriptive leaflet GEA-4630. *General Electric Company, Schenectadv 5, N. Y.*

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GENERAL ELECTRIC

FOX

One of the fine things of this world....

"WE believe that you can buy common things and fine things in this world. One man chooses the common, and gets a fleeting satisfaction for having paid so little. Another chooses the finest, and gets the lasting satisfaction and the better bargain for having paid so little more for so much more."

- You can mow, chop and load, in one operation, over 200 tons of grass silage a day.
- You can cut corn of any height, chop it into silage and load into wagons ready for the silo, all in one operation.
- One man can pick up, chop and load, ready for the mow or stack, 2 tons of dry hay in 12 minutes.

Any of the many enthusiastic users of the Fox Forage Master could have written the above quotation. For the Fox Forage Master has saved them much sweat and backache on the three hardest jobs of farming, haying, forage harvesting, and silo filling. Built by the Pioneers of Modern Forage Harvesting and backed by over ten years of successful field operation, the Fox Forage Harvester together with the Fox Crop Blower takes the backaches out of haying and silage making.

Write us today. We will be glad to tell you all about this marvelous machine.

R. G. Krueger Secretary

FOX RIVER TRACTOR COMPANY

Pioneers of Modern Forage Harvesting

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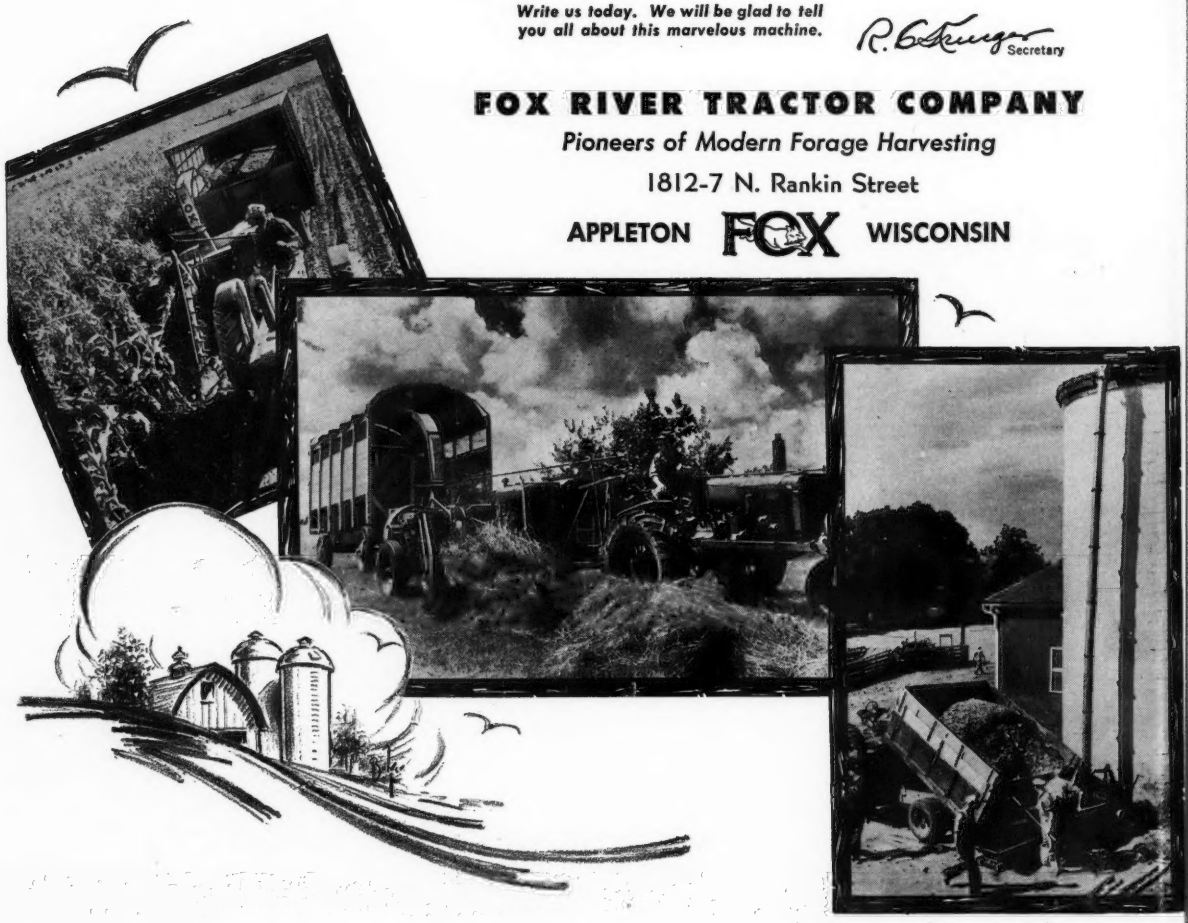

Why 8 out of 10 tractor owners prefer gasoline

Operating convenience. Besides delivering more power than any other fuel, gasoline is the most convenient to use. A gasoline engine starts quicker, warms up faster, idles better. This is why, with all fuels to choose from, eight out of ten tractor owners prefer gasoline.

Gasoline gives best performance when used in an engine specifically designed for it. With high compression and gasoline, a farmer can pull more equipment and work more acres in a day. Over half of all tractors in service today are high compression, gasoline models.

Among the latest of the tractors especially manifolded and carbureted for gasoline is B. F. Avery Model "V." Its four-cylinder "L"-head high compression engine assures efficient, economical operation. Model "V" is designed for small farms and as auxiliary on larger farms.

When you recommend a high compression tractor, you are helping the farmer look ahead. You are making sure that he is getting the extra reserve of power he needs to provide for expanded operations in the future, as well as making more money today. *Ethyl Corporation.*

Specialists in Manufacturing to Customers' Specifications

OHIO RUBBER CO

Better Results with Rubber thru Research and Engineering

Typical Products Made for Industry Everywhere in the U.S.A.

AUTOMOTIVE PARTS

Boots
Bumpers
Channels
Fender Guards
Gaskets
Grommets
Mats: Contour
Mats: Flat
Mats: Carpet Inserted
Pedal Pads
Running Boards
Sill Mats
Step Plates
Tubing
Weatherstrips
Wiper Blades

RUBBER-TO-METAL

Beater Bars (Farm Mch'y)
Bumpers
Pedal Pads
Running Boards
Sill Mats
Step Plates
Tractor Shoe Blocks

RUBBER BONDED TO:

Aluminum 2S and 3S
Black Iron
Brass 70/30, or less
Bronze
Cadmium Plate
Cast Iron
Chromium Plate
Copper
Dow Metal
Galvanized Iron
Lead
Stainless Steel
Terne Plate
Zinc
Carbon
Wood
Fibre (Vulcanized)
Celotex
Glass
Plastics

HOSE (All Rubber)

Drain
Heater
Washing Machine

MOLDED GOODS

Boots
Bumpers
Conductive Rubber
Diaphragms
Gaskets
Grommets
Gun Recoil Pads
Laminated Door Panels for Refrigerators
Milking Machine Inflations
Oil Well Supplies
Screw Bumpers
Small Hard Rubber Parts
Treadles
Valve Cups
Valve Discs

EXTRUDED GOODS

Bumpers
Channels
Gaskets
Glass Setting Strips
Rollers
Tiring
Tubing
Weatherstrips

HARD RUBBER

Casters (Light Duty)
Casters (Heavy Duty)
Handles
Small Molded Parts
Toys
Valve Discs

RUBBER ROLLERS

Business Machines
Farm Equipment
Lawn Mowers
Textile Machinery

MATS

Automotive (Contour; Flat; Carpet Inserted)
Ladder
Scale
Scooter

DEFROSTER AND VENTILATING HOSE

Full range for length and O.D.

VIBRATION ABSORPTION AND MOUNTINGS

Engine
Machinery
Motor
Vibration Absorption and Isolation Parts

TUBING

All sizes and shapes to customer's specifications

GRIPS

Bicycle
Control Rod
Fishing Rod
Lawn Mower
Motorcycle
Outboard Motor
Scooter
Tricycle
Tubular
Vacuum Sweeper
Velocipede
Wagon

SEALS

Dirt
Grease
Oil
Silicone
Water Pump

WHEELS

Casters (Light Duty)
Casters (Heavy Duty)
Industrial Wheels (Molded and Pressed)
Toys

TIRES

(Solid Molded)

Automobile (Junior)
Baby Carriage
Caddy Cart (Golf)
Coaster Wagon
Garden Cart
Hand Trucks, Etc.
Industrial Vehicles
Lawn Mower
Misc. Portable Equipment
Scooter
Toy
Velocipede

AIR KING TIRES

(Semi-Pneumatic)

Light Duty

Sizes from 8" x 1.25" to 20" x 1.75"

Typical Applications:

Automobiles (Junior)
Baby Carriages
Caddy Carts (Golf)
Coaster Wagons
Garden Carts
Hand Trucks, Etc.
Industrial Vehicles
Lawn Mowers
Misc. Portable Equipment
Scooter • Toys
Velocipedes

Heavy Duty

Sizes from 6" x 2.00" to 16" x 4.00" with respective load ratings from 150 lbs. to 625 lbs. Other sizes and load ratings made to specifications.

Typical Applications

Aisle Marking Machines
Arc Welding Machines
Barrel and Drum Trucks
Battery Charging Machines
Car Washers
Contractors' Pumps
Cooling Fans
Floor Sweeping Machines
Hand Trucks
Hospital Equipment
Insecticide Sprayers
Lubricating Equipment
Paint Sprayers
Tote Trucks
Traffic Line Markers
Sidewalk Snow Plows
Wheelbarrows
Misc. Portable Equipment

TIRES

(Extruded Tubing)

Automobile (Junior)
Baby Carriage
Caddy Cart (Golf)
Coaster Wagon
Garden Cart
Hand Trucks, Etc.
Industrial Vehicles
Lawn Mower
Misc. Portable Equipment
Scooters • Toys
Velocipede

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EDITORIAL

Engineering Interpretation of Human Problems

SOME few agricultural engineers have found their fields of work and opportunity broadened and extended outside of this particular specialization. One such is L. J. Fletcher, a past-president of A.S.A.E. We are happy to report that, while his direct contacts in our field and Society have become fewer, he has increased his effectiveness as an ambassador of agricultural engineering to the rest of the engineering profession, and as an interpreter of engineering and free enterprise to his home community.

In an address before the last semiannual meeting of the A.S.M.E., recently published in "Mechanical Engineering", he presented the unique opportunity of the engineer to interpret free enterprise to his neighbors, in part as follows:

> "Another reason why the engineer must assume responsibility in this field of developing understanding is the simple fact that, through his demonstrated performance in peace and war, he has won the confidence of the general public. The promises of the engineer are fulfilled, his buildings stand, his machines operate, his airplanes fly. He is in a position of great influence. He has not yet placed himself on either side of this controversy (free economy vs. dictatorship). His habit of analyzing, his factual presentation are vitally needed now. He has learned to discuss matters without emotion. He is a good listener. He has friends in all walks of life. He lives in all parts of this great land — the cities, the towns, and the country. My sincere hope is that this message may help even one more engineer to see his responsibility. I have every confidence that what he does about it will be good. . . .
>
> "First, I suggest that you work at home. Work in your own community where you know people. After all, the community is the only real unit of society in the world. In fact, your state, this nation, or even the world is simply the sum of all its communities. It is within the community that real understanding can be recreated, for here people see each other, and by seeing people day after day real friendships can be developed. If our communities are bound together with the cement of understanding and friendship, no wedge of distrust or hate inserted at the national level can tear us apart.
>
> "The engineer is traditionally a man who has worked for things rather than against things. In my field of agricultural engineering we have been for labor-saving efficiency in agricultural production, not against primitive agriculture. So here the engineer does not need to take up the banner against a philosophy, a group, or even an individual. Look what we have to work for. We know the demonstrated effectiveness of our system of free economy when wisely regulated by good laws. That is what we are for, and we can help interpret all its benefits as it affects every individual."

We believe we see in this some support for the conjecture that engineering techniques might be extended and adapted to practical utility beyond the range of the strictly physical factors in human activities. Can the engineer satisfy himself that his techniques could produce or prove solutions in this broader field which would justify public confidence? How comparable to the purely physical are the forces, materials, motions, and organizations involved? It occurs to us that engineers might find it worth while to play around with ideas of engineering surveys of human objectives; the load capacity of a foundation of understanding; the trussed strength of a framework of principles; the mechanics and dynamics of human organization.

Should not engineers be among the first to recognize and propound the individual-motor-drive characteristics of the human being? Are the fuel of incentive, the spark of initiative, the individual and collective governing forces of human action, and the steering gear of objectives necessarily beyond the range of understanding by engineering techniques? Are the laws of social stability materially different from those of physical stability? Are the coefficients of social friction incalculable?

Is the measurement of actual and potential market demand, for example, essentially different and more difficult than some of the other measures of intangible forces achieved by engineering procedure and instrumentation? Are prosperity and depression conditions impossible of analysis into their component factors? Does a combination of human forces acting in various directions defy engineering computation of their resultant? Can the power surges of public opinion be directed into useful work?

By exploration into possible new fields of usefulness, engineering has advanced considerably beyond its original service in implementing war. One direction of exploration produced agricultural engineering. Another, beyond the boundaries of recognized physical science, offers some promise of smoothing the road for beneficial engineering applications of physical science.

Implications of Economic Demand

CONTINUING postwar world shortage of food and other products re-emphasizes the extent to which desirable living conditions, as we have come to know them, depend on continuing and increasing high productivity in agriculture and other industries.

Some of the general implications of this dependence, to agricultural and other engineers, and through them to the general public, appear to be as follows:

Primary source materials of production will command even more attention than they have in the past. Little or nothing about them, as to their supply, component parts, properties, possible combinations, or potential use will be taken for granted by engineers.

Various exhaustible resources will be considered more and more as public trusts, to be developed, used, and conserved for the greatest public benefit.

Inexhaustible resources of energy, uses and combinations of the abundant elements, and the renewable resources of organic chemistry will be developed to reduce dependence on exhaustible resources, and to provide new products and improvements not otherwise possible.

The mechanics of production, with both old and new source materials, will be further intensified to increase the effectiveness of human labor, and to concentrate its application toward the exercise of human discretion in the development, manipulation, direction, and control of mechanical operations, and in associated human relationships.

Power and materials will be used in increasingly automatic devices for measurement and control of the environments of production; for increasingly delicate manipulations as well as for tonnage movements; for finishing touches, inspection, and routine testing in mass production.

Human organization for more effective production will be the subject of numerous experiments and a lot of wishful thinking. The whole range of combinations from individual self-sufficiency on one extreme to state socialism on the other, will be tried repeatedly and with familiar variations and results.

Most engineers, we believe, will agree that a genuine unity of purpose, on the part of all members of a producing unit, is the key to human organization for effective production. It is our understanding that this has been achieved and maintained with notable success in a considerable number of small organizations and some fairly large ones, by policies and procedures which will bear study and emulation.

Agriculture and agricultural engineers are fortunate in that many of their producing units are still small and flexible enough to have or to achieve and hold this unity of purpose with a minimum of difficulty. There are exceptions, notably in areas and types of farming requiring large amounts of transient labor; in some of the industries which are agriculture's sources of supply; and in others which handle farm products. These only emphasize the opportunity and responsibility of agricultural engineers to work for human as well as physical organization for efficient production.

HOG-TYING STORM WATER TO A WHEAT CROP
Pulling four 5-shovel John Deere lister-chisels working 10 inches deep, this Diesel D7 tills 10 acres of wheat land per hour. Outfit is owned by C. T. Peacock, Arriba, Colorado.

Drouth does not bluff C. T. Peacock, Arriba, Colorado—for he has raised wheat crops with his summerfallow system even in dry years, when total failure was general in his area.

Heart of the Peacock system is the use of the heavy-duty lister-chisel of his design. The picture shows Mr. Peacock's "Caterpillar" Diesel D7 Tractor pulling four of the 5-shovel lister-chisels—working the soil 10 inches deep.

Note how rough and cloddy this operation leaves the ground, to resist wind erosion— yet it is opened far below normal plowing depth, to "drink" water like a sponge and prevent loss by run-off. Storm water is literally "hog-tied" in the soil on which it falls!

The lister-chisel operation is preceded by early-spring disking of the stubble and is followed by fast cultivations to keep the fallow weed-free till seeding time. And seeding is done with deep-furrow drills. This method works for C. T. Peacock!

The grain-grower who hitches a successful summerfallow method to the correct size of "Caterpillar" Diesel Tractor commands important advantages. Ample drawbar pull to do his primary tillage extra well. Positive traction, on soft summerfallow to pull extra wide cultivator hitches for speedy moisture-saving weed-control. And on the deep-cushioned seat of this modern Diesel tractor, he farms with those who set the world's economy pace!

CATERPILLAR TRACTOR CO., PEORIA, ILL.

CATERPILLAR DIESEL

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